

THE IMPULSE GENERATOR

Dr. Evgeny Podkletnov on the Impulse Gravity-Generator

By Tim Ventura & Dr. Evgeny Podkletnov, April 10th, 2006

In 2001, Dr. Evgeny Podkletnov began publishing a series of scientific papers detailing the experimental results of what he called an “impulse gravity generator”. The device reportedly produced hundreds of pounds of gravitational force in a non-diverging beam, capable of “punching holes through concrete and warping metal like hitting it with a sledgehammer”. Podkletnov further added that this beam produced no recoil on the superconducting emitter itself, and that a radiation had been produced behind the device creating a molecular juxtaposition between plastics, metals, and living tissues similar to that described in the Hutchison Effect. This document is the result of 3 interviews between 2004 and 2006 that attempt to document and further clarify his remarkable experimental claims...

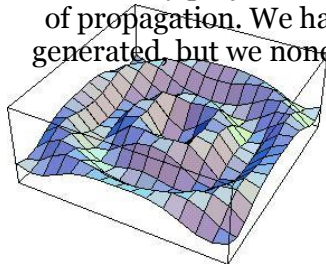
AAG: Thanks again for taking the time to speak with us about your research; it's truly been pioneering in the field of superconductive antigravity. A lot of the papers that I read online – and a lot of the references – date directly back to your research from the early 1990's, and more recently your experiments with Dr. Giovanni Modanese. Is there anything that you can tell us about what you've been up to lately?

Podkletnov: My research is based on the idea that it is possible to change or to modify the local gravitational field, and to consequently change the gravitational properties of objects within that field to make them lighter or heavier. This all can be done by creating special conditions in what might be described as the polarization of the ubiquitous vacuum, or by modifying the curvature of Einstein's space-time. There are several ways to do this – we can use high-voltages, large magnetic fields, and extremely high-speed rotation of various objects. We can also take advantage of topological effects in superconductive materials. Altogether, there are a number of possibilities, including potential combinations of some or all the parameters that I've just described.



Dr. Evgeny Podkletnov: Specialist in Type-II superconductive gravitomagnetic systems.

My latest experiment is a device called the “gravity impulse generator”, which utilizes a Marx-Generator discharge through a superconducting emitter in a high-magnetic field to create a wave in time-space with properties very close to gravity-waves. The similarities are apparent enough we're almost positive that it actually is a form of gravity. These impulses can be directionally projected in any direction in space, and they exert a force on any object in the path of propagation. We haven't quite uncovered a detailed mechanism to explain how this force is generated, but we nonetheless have the technological possibility for industrial and commercial applications of these results, and this is



HFGW: A High Frequency Gravitational Wave model.

the most important.

AAG: You'd mentioned that this effect generated hundreds of pounds of force in a very short period of time, and I'd wondered if

this effect has been able to punch holes through lightweight substances, or does it produce more of just a motion on them?

Podkletnov: The force of the impulse depends entirely on the structure of the superconducting emitter and the voltage that we apply to it. Given the materials & voltages we currently have available, we can obtain large impulses capable of deforming metal plates with a thickness of a couple of inches, and we've also been able to demonstrate punching holes in thick concrete walls. Obviously these effects are not limited to just lightweight substances – a concrete wall is something very solid. The impulse deforms metal in the way that a hydraulic press might do it, but the pulse-duration is very short in time, so we've been discussing a system utilizing several Marx-Generators to give a series of impulses that will definitely improve the overall effect. We've experimented with using the impulse-generator to treat a variety of materials, and we've also made another important find: the beam can hit a target over very large distances with a minimum of divergence and what appears to be zero loss in energy, even after passing through other objects in the beam-path.

By using extreme parameters we can create an even larger impulse forces. We discovered in the last year and a half that if we go to 5 -million volts we can generate hundreds of pounds of force. At that time, we were also trying to measure the speed of propagation for these impulses. The results were extremely interesting, and hard for even us to believe, because to some extent it contradicts many aspects of modern physics. Nonetheless, we have experimental proof, and we're going to continue developing all of these experiments.

AAG: Oh, so these are all generated by Marx-Generator discharges?



Marx Generator: An example 2 megavolt model constructed by Information Unlimited.

Podkletnov: It is possible to use high-voltage discharges up to 5 million volts and specially prepared superconductors. These impulses are very short in time, we're talking about 1 millionth of a second and shorter, and they can be very powerful, and can be used for rocket propulsion in space. At the same time, they can be used for the correction of satellite orbits from the earth with minimum expense, making this a very promising technology.

AAG: In terms of putting holes through concrete, it makes sense that the holes would remain, but with metals, after the metal is deformed, do they snap back after the beam is gone, or do they remain deformed?

Podkletnov: No, they just remain deformed. It's just like a punch – very short in time, so it's close to an explosive action or something like that.

AAG: One of the things that I was wondering about is whether you've been able to do efficiency calculations for the force-beam.

Podkletnov: Well, Dr. Giovanni Modanese made some preliminary measurements that gave us the force in joules, but we did not try to make predictions – we wanted to simply see the results of how different objects reacted to the action of this impulse, so we didn't make any precise calculations.

AAG: The type-II YBCO emitter measured 47mm in diameter, if I remember correctly. Does changing the size or the shape change the beam output – maybe making it stronger or refocusing it?

Podkletnov: Well, in terms of the size of the superconducting emitter, there are some limitations. The diameter of the superconductor shouldn't be smaller than 4 inches, because of the Schwartzchild radius. Now to answer your question, in terms of the shape of the emitter, the superconductor can in fact have different shapes, and the projected impulse will maintain the emitter's cross-sectional shape, so is important.

AAG: The 4-inch minimum size for the superconductor seems to limit the public's ability to perform experimental replications. The largest commercial available superconductor that I've seen is a 1" superconductor – so it sounds like the emitters require custom fabrication?

Podkletnov: Well the size is very important – we didn't get any good results with smaller superconductors, and it's also more difficult to create the correct flat-glow discharge with smaller superconductors.

AAG: Have you noticed any changes in the molecular structure, internal materials deformation, or maybe simple mechanical compression in the targets that you'd sent the beam through? You'd mentioned metals deforming and holes through concrete...

Podkletnov: We didn't see any compression effects or any change of the molecular structure – just a large scale deformation of the target material from the beam's force.

AAG: I should ask whether the beam loses energy as it penetrates materials. Does it naturally decrease or diverge with distance?

Impulse Gravity Generator (initial setup)

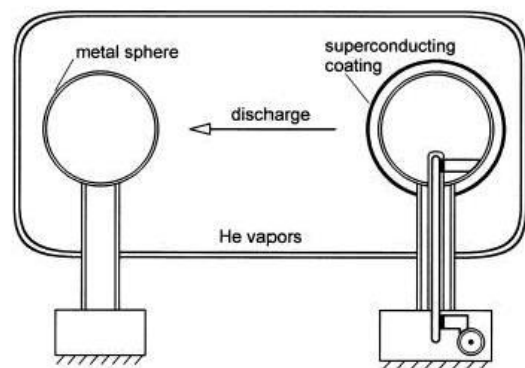


Fig. 1

Impulse Gravity Generator (improved variant)

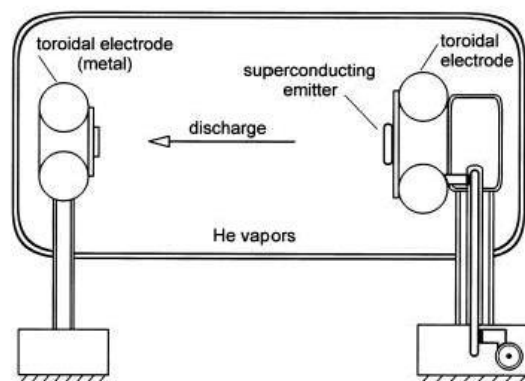


Fig. 2

Emitter Configuration: Schematic of two superconducting emitter apparatus designs.

Podkletnov: That's an interesting question...and to our great surprise the beam practically does not lose energy when it meets the materials. It can pass through a brick wall or concrete, or metal-plates – very thick ones – or plastics also, and it seems that it doesn't lose energy at all. This is the consistent, long-term evidence from a lot of test discharges we performed at an installation I've been working at for about 4 years.

These results seem a bit strange, but we don't believe we're breaking any natural laws...simply that the system we're working in is not a closed one, and therefore the second law of thermodynamics is not applicable in the traditional sense.

In terms of action at a distance – and the dependence of distance on the beam energy – we don't have much experimental data, but what we do have is a first measurement at a distance of 1.2 kilometers without any loss in energy. Our latest experiment was conducted over a distance of 5 kilometers, and the beam penetrated through several houses made of concrete. We did not measure any loss of energy, but after closely evaluating some of the calculations that we've made, we should get some decrease in beam-energy at distances greater than 100 kilometers. This is research that awaits us in the future.

AAG: You'd mentioned 5 kilometers – did you notice any change in the focus of the beam. Did it widen or perhaps get smaller as it travels?

Podkletnov: If the main solenoid which is wound around the chamber is made in a good way, then we have a very good discharge and it effectively maintains a non-divergent cross-sectional pattern of the emitter it was projected from. However, at a distance of 5 kilometers, the beam begins to lose focus– it gets a bit wider than it was, indicating minor deviations in the shape of the impulse as it propagates.

AAG: I collected a few questions online, and one person wrote me, "Is it possible to generate more work along the path of the beam than energy put into the beam?" I think they were asking about potential "over-unity" applications.

Podkletnov: It's been surprising to find that the energy that we put into the discharge is much less than the energy that the impulse seems to generate, but it doesn't mean that it's an over-unity device, simply that we're creating a set of special space-time conditions through the interactions of the electromagnetic pulse-discharge with the bose-einstein condensate (superconductor). By manipulating these

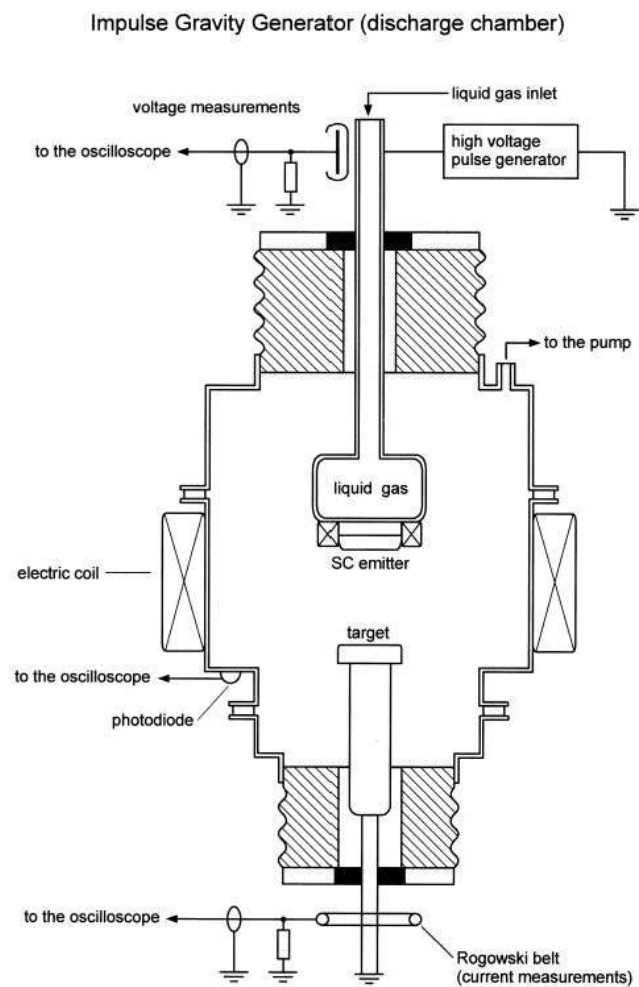


Fig. 3

Discharge Chamber: A complete layout-schematic of the chamber showing experimental components.

parameters we allow the interaction of electromagnetic fields with the sub-atomic field environment. We may call it zero-point energy or maybe even aether, but whatever it is, when normal matter interacts with it this special energy is obtained, and we can harness this energy. Our technology may be like a key that opens the door to the energy of the subatomic realm. This is at least our fervent hope...

AAG: Does the impulse-generator seem to defy conventional Relativity Theory? I'm wondering if you might have any specific examples or observations of things that Relativity Theory simply can't explain...

Podkletnov: I would never say that that our experiments defy conventional Relativity Theory because they don't. You know, people also suggested that about my earlier experimentation with the rotating disks, but in that case the rotations around the disk's own axis are absolute rotation. This is absolute movement, not relative, which is why relativity theory is not applicable to our rotating disks – it's a totally different thing. However, I don't think the force-beam experiment defies Relativity Theory either.

AAG: Does the inertia change in proportion to changes in mass? The reason that I wrote that down was really in relation to Fran De Aquino's research. He believes that inertial & gravitational mass are not equal, they just appear equal to us in our frame of reference.

Podkletnov: Well, based on our understanding and our experience, we didn't differentiate between gravitational and inertial mass, and we believe that they are equal. Experimentally, the puls-width of the impulses is too short to notice any difference, and we never conducted any special experiments just to distinguish gravitational and inertial mass.

AAG: In Relativity Theory, gravitation and time are integral components of the "fabric of time and space" –and modifying one inherently changes the other. Given your description of the impulse-beam as being gravitational in nature, have you noticed any experimental time effects?

Podkletnov: It's difficult to say, because in a practical sense it's not truly a gravity-beam – it's a gravity-impulse with a very short time-duration, and because of this limitation -- because it has such a short pulse-width -- we didn't notice any time effects and didn't even try to measure them, but it's possible they are present. These effects were definitely present when we were experimenting with the rotating disks – definitely – and we had some experience with this, but with the gravity impulse-generator we simply didn't conduct any measurements.

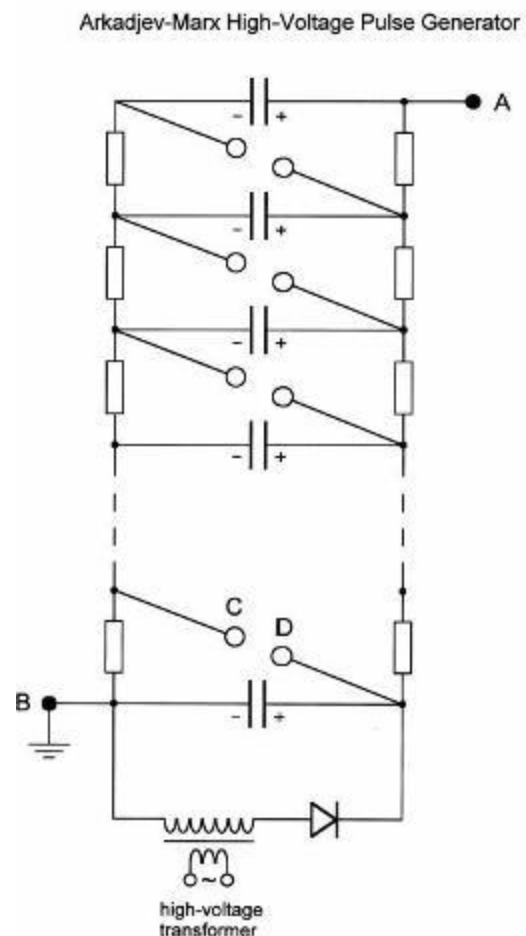


Fig. 4

Marx Circuitry: An overview of an idealized circuit for the Marx-Generator.

AAG: Now you've mentioned working on some scientific publications, and I'd like to find out more about what topics you plan on publishing about in the future, and what your schedule for publication might be?

Podkletnov: Well, of course there is a growing interest in the concept of manipulating gravity in a number of countries. For instance, we got a very interesting offer from China-- they have a very special project at the University of Beijing – and there's also been some interest from the private sector in the United States as well.

As soon as we get funding we'll try to publish on a variety of experiments in a more detailed manner, but at present we're extremely interested in attempting to measure the interaction of the impulse-beam with visible light, and we published some preliminary results about this in the journal of low-temperature physics in August of 2004. The details are all in my article with co-author Dr. Giovanni Modanese, and we're continue this research now, again with a focus on attempting to measure the propagation speed of the impulse.

We're very cautious about what we write, because we don't want to frighten the scientific community, and also we want to be absolutely sure that the results are checked and rechecked several tens of times-- but it seems that based on what we have now, and we've already been working for a year and a half, the speed of the impulse is much higher than the speed of light.

With the parameters that we use now – using our current emitter designs and a voltage of 3 and 5 million volts, the speed is about 63 to 64c – which means that the propagation speed of the impulse is close to 64 times the speed of light. Of course, we would like to measure all these parameters using different measurement systems and different approaches. At present we use two atomic clocks, and we think that our measurements were precise enough, but we would welcome the advice of the international community. It would help to have additional input on how to measure the speed of the impulse in a very specific way. As soon as we get a good confirmation of these results, we will try to publish all of this information.

Pendulum in a Glass Cylinder under Vacuum

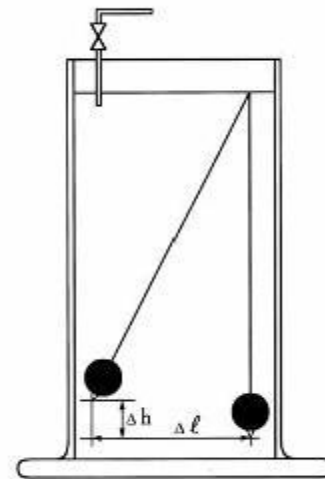


Fig. 5

Pendulum: Podkletnov's initial force-beam experimental measurement apparatus.

AAG: I was wondering about funding: you've mentioned that there was interest from the private sector in the United States and from China – do you know if there are any replication efforts underway by other groups to duplicate your research?

Podkletnov: I know that there was a lot of interest from Boeing, but I don't know the details. I also know that the Department of Defense in the United States is very interested in this technology, and that's why they invited Dr. Ning Li to lead the scientific laboratory funded by AMCOM, but at present I don't know of any official replication of my gravity experiments. This is because my research is rather hard to categorize, it's costly, and the official attitude of the

“politically correct” scientific establishment towards gravity-modification is negative, which creates a lot of difficulties.

However, I don’t hide anything, and when people contact me directly or by email I usually try to give all the advice that I have and to share my experience with them. The problem is too complicated for one country or for one lab to succeed; gravity should be studied all over the world using the best forces and the brains of difference scientists. That’s the key to success.

AAG: I think we’ve already agreed that one of the chief obstacles to a successful replication is the 4-inch superconductor – do you know if those are manufactured and sold anywhere, or is that a process that everyone has to go through to build their own?



Dr. Modanese: Podkletnov’s research partner, physicist, and force-beam co-author.

Podkletnov: Frankly speaking, in the case of extremely effective emitters that’s a part of my professional know-how, but if you’re only talking about emitters that allow you to generate small effects, then it’s not a problem. I believe that American Superconductor can help to easily make emitters of this kind, and also there is a nice firm called “Superconductive Components” in Columbus, Ohio – they’re more or less familiar with my technology, and I think that they are up to the task of building emitter components.

AAG: So essentially, by using a smaller superconductor you have a smaller effect, but that can be tested by using more sensitive equipment.

Podkletnov: The diameter of the disk should still not be less than 4-inches, but I’m talking about the physical structure of the ceramic itself. The structure for efficient emitters is very difficult to build, and requires a lot of experience to build correctly, so even if I provided a detailed description, it would be difficult to construct without my help. Normal emitters which allow you to push a thick book away from a table are possible to construct, as they aren’t quite so complicated.



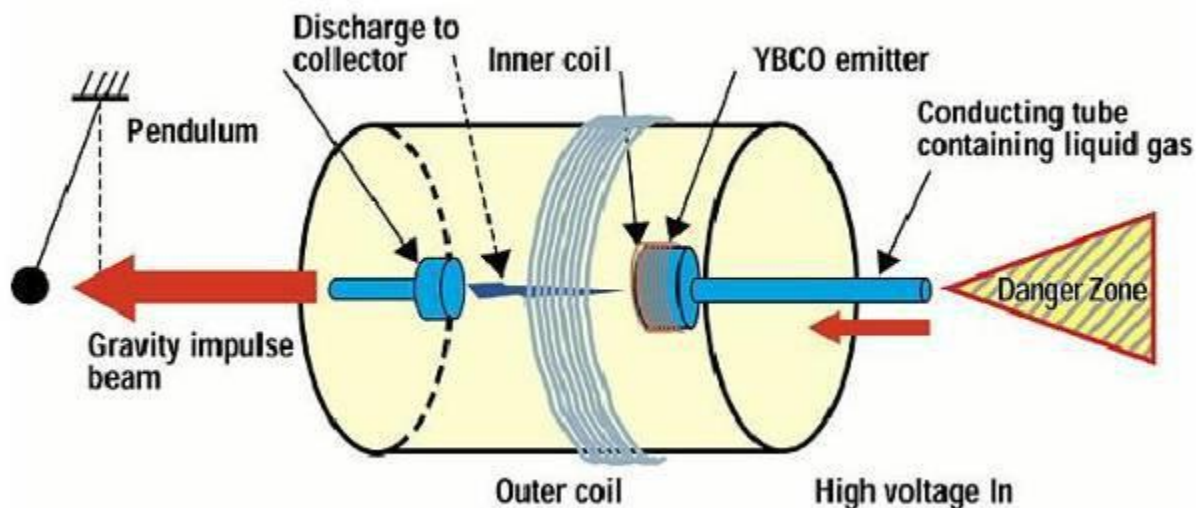
Dr. Ning Li: A colleague of Podkletnov’s and specialist in gravitomagnetic coupling effects.

AAG: I had a question from another person who was asking about video, but they were also asking about a flat-glow discharge.

Podkletnov: Well, in order to make a video for the flat- glow discharge, we should use a high-speed video camera that we don’t presently have, so we typically have to rely on our keen sight, but it’s a bit difficult. We’re planning to film it, but even with a normal discharge – a spark, as in a van de graaf generator, or in a flat-glow discharge, which repeats the configuration of the emitter, it’s possible to see it with your own eyes -- you don’t need a camera for that.

AAG: Now in terms of experimental setup, because I'm getting ready to buy parts...it looks like, from reading through your experimental setup, that essentially you're discharging a high-voltage onto a superconductor – that, and the superconductor itself is inside a magnetic field. It looks in some ways deceptively simplistic, but I understand that there is a definite challenge involved with it. Have you found any real tricks to testing with this?

Podkletnov: Well, this technology is really nothing special, but I work with a team of experienced people who are experts in high-voltage discharges, experts in ceramic materials & superconductors, and experts in magnetic fields, and only by combining the knowledge different fields and people from different countries can we reach something positive. This international collaboration becomes inevitable, and becomes the key to success.



Emitter Experimental Setup: An overview of the emitters subjected to a high-voltage discharge.

AAG: Dr. Bob Baker is working on putting together a 2006 High-Frequency Gravity-Wave Conference as a follow-up to the earlier one in 2003. Has he contacted you about this, and would you be open to attending?

Podkletnov: No, he hasn't sent me anything. You know, I have a job here and I don't want to risk it, especially without firm opportunities for funding. I'm hoping to find investors wise enough to see how much money this research can generate. Unfortunately, up to now they don't understand it – if I release this technology, if they put money in it – then we will definitely succeed in it, and in 2 or 3 years they will be richer than Bill Gates, but this understanding comes very slowly. We've been hoping for commercial funding, because the impulse generator is basically a gravity-gun, and I'm not really interested in providing a weapon of strategic importance to the United States. If we're talking about new propulsion systems, though, I'm eager to share my knowledge. Of course the gravity-beam can also be used for propulsion, but the rotating superconductor can be used only for creating propulsion – a vertical column to help lift a craft off the surface of the earth.

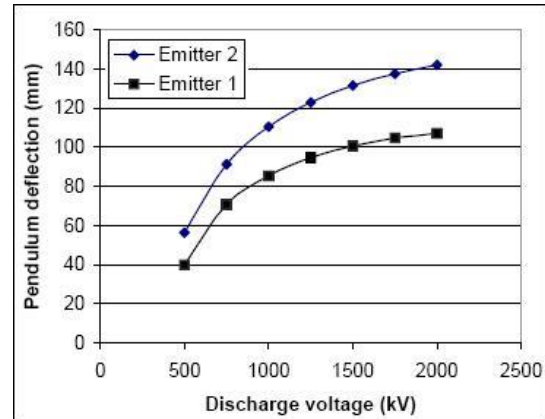
AAG: The force-beam that you'd mentioned coming out of the back of the impulse generator had a negative effect on living organisms, right?

Podkletnov: Yes, it produced a strange kind of non-focused radiation that was very harmful to biological tissue -- fortunately for us; the impulses were very short in time. It was very harmful to living organisms; we also observed a melting or molecular-juxtaposition effect of biological tissues with plastic materials, and even with metals to some extent.

AAG: So this was a very different force than the impulse coming out of the front of the generator?

Podkletnov: Yes, it was an entirely different force, and it was not focused like the gravity-beam.

AAG: In “The Hunt for Zero Point”, Nick Cook described an experiment in the 1940’s called the “Nazi-Bell” that reportedly exhibited side-effects like the crystallization of cell-membranes in plants and the breakdown of living tissue into a greasy substance after repeated exposure. Does this sound similar in any way to what you saw emanating from the back of the impulse-generator?



Deflection: Deflection of pendulum during testing as a function of discharge voltage.

Podkletnov: Well, I can’t speak for what they might have seen – during the 40’s I hadn’t even been born yet! However, it might be that the side-effects are similar to ours. There are several effects that are similar to this – one is the Hutchison Effect, where he reported molecular distortions & materials juxtapositions, which is similar to the anecdotal claims of “sailors melting into decks” in the Philadelphia Experiment legend.

AAG: Oh, so you’re actually talking about a radically different set of associated effects...did you witness anything like atomic transmutations or Low-Energy Nuclear Reaction (LENR) effects occurring, or just the molecular-level anomalies?

Podkletnov: Well, the radiation that emanates from the rear of the impulse-generator might somehow create conditions suitable to LENR effects, but this wasn’t an area of focus in our research, so I really don’t know. Our primary focus was on studying the gravity-beam itself.

AAG: In terms of the force-beam, you’ve said that it was hundreds of pounds of force, and I realize that it was very difficult to measure. You’ve said that it was also enhanced with 5-million volt discharges. Can you tell me a bit more about this?

Podkletnov: Yes, its output force depends on the voltage and also on the effect of how sharp the impulse is. If the rise-time of the impulse is long in duration, then we have a lower-power impulse, and if it is very sharp – I mean the voltage rises very fast – then the effect is very large and is able to bend metal plates.

AAG: Ok, did you test on anything besides metal or concrete, to try some other substances?

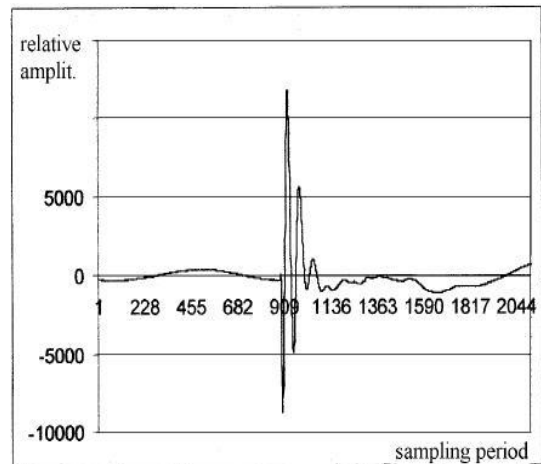
Podkletnov: It's not a drilling-machine, sorry. We're interested mainly in the use of this technology for propulsion in space, and frankly speaking it really is what you'd call "propellantless propulsion".

AAG: Let's focus on that for a second: when you noticed the impulse force on objects in the beam path, was there an equal & opposite force on the superconductor itself?

Podkletnov: No, there wasn't. There was no reaction force at all.

AAG: So if you put the superconductor inside of a spacecraft then, I guess that it wouldn't produce a conventional forward propulsion?

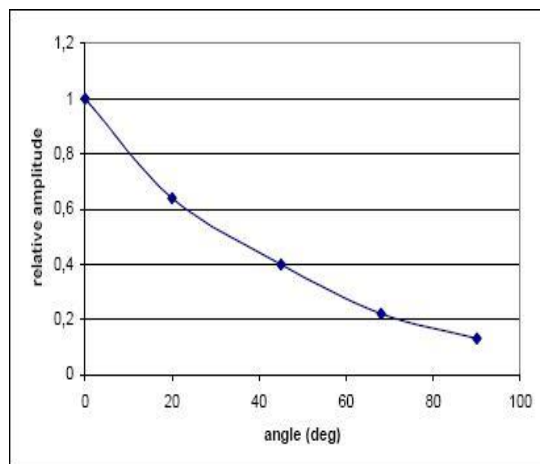
Podkletnov: Yes, it doesn't act according to Newtons third law – that every force has an equal and opposite reaction. But simply the superconducting emitter, whether it is a rotating disk or the discharge-system, is able to create a gravitational wave in what you might call the aether or the space of subatomic particles. Or you call it a gravity-wave. So this wave propagates through space, through all the objects, sometimes it can interact with normal matter, but to my surprise it does not lose its energy at very high distances – it remains collimated as it propagates.



Amplitude: Relative pulse-amplitude from impulse-discharge experimental testing.

AAG: Did you notice any other strange effects in the general area? Anything in addition to the impulse itself, the effect on objects, or the strange radiation coming out behind?

Podkletnov: No, we didn't, but frankly speaking it is not very easy to measure all these additional effects. You know, when you're dealing with millions of volts, it's better to keep a bit of safe distance. We use a faraday cage and special rubber-metal coatings to shield the radiation, because otherwise the high magnetic field strength from the discharge will erase computer hard drives and damage nearby test-equipment.



Deflection: Angle of pendulum deflection correlated with adjusted pulse amplitude.

AAG: When you analyzed the metal sample that was bent with the gravity-beam, did it appear to be only bent forward in the direction of beam propagation? Dr. Bob Baker postulates that gravity-waves may be quadripolar in nature, and I'm wondering if these waves might leave a detectable signature in the materials they deform to help validate his theory...

Podkletnov: In our experiments we were able to observe only the forward action.

AAG: Do you think that there might be any torsion physics involved with the impulse-generator?

Podkletnov: I think that torsion or axial fields may be present in our experiments, but it's more suitable to suggest a role for torsion physics in our original rotating disk experiments - the mechanism behind the impulse-generator is a bit different.

AAG: Speaking of which, in terms of the failed NASA replication for the rotating-disk experiment, I'd heard from a NASA insider that they only spun it up to about 200rpm. Does that mean that they didn't fully complete your experiment?

Podkletnov: I cringe every time I hear that NASA failed to replicate my experiment, because no, they didn't fail. They made their own disks, and they were big enough: about 12 inches in diameter. They published some initial test information indicating that they had definitely noticed some unusual effects. Then I got involved in participating to helping them to replicate my experiments, and they practically had everything ready when they ran out of money. So at the last stage they were not able to rotate the superconductor in the magnetic field, and shortly after that the department of defense came in and grabbed all the experiments. All of this research was transferred to Dr. Ning Li – so now NASA has nothing, and we have nothing either.

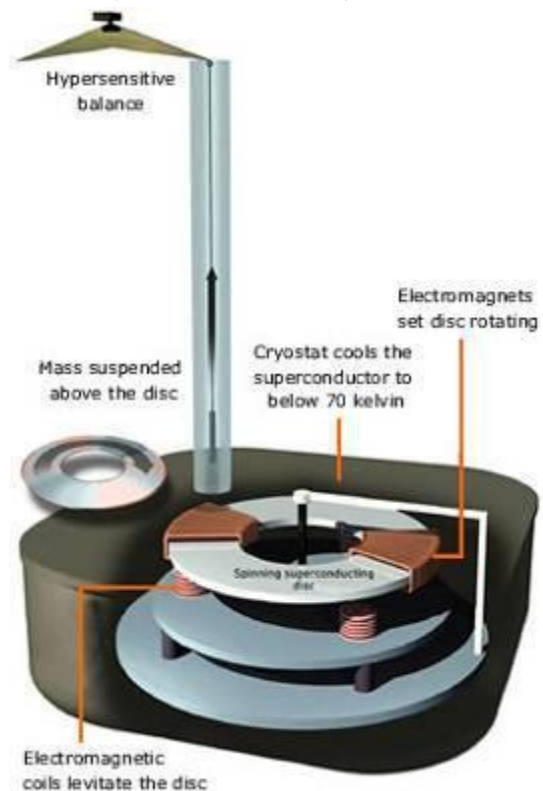
AAG: So is Dr. Ning Li still in charge of the project then?

Podkletnov: I think so, but the point is that NASA never completed the experiment, and thus nobody can claim that they failed to see results, because they never completed it.

AAG: Have you ever been approached by the Department of Defense for any kind of funding?

Podkletnov: No, they would not do it. I am a citizen of Russia so they wouldn't even try.

AAG: Well, the Chinese, though, have a gravity-lab: have they expressed any interest in your research?



Rotating Disk: A cutaway of the Type-II disk apparatus from the first experiment.

Podkletnov: They expressed real interest and they've invited me to China several times, but they are like kindergarteners: they want me to come just and give them completed technologies. They have a rather good theoretical school but they haven't achieved much in practice, and they seem rather limited in funding, so I am not eager to travel to China and work there at my own expense.

AAG: Have you ever been able to gravity-research lab in China? Bob Baker visited a couple of years ago, and was impressed by their efforts.

Podkletnov: No, but I'm perfectly aware of the projects they have and their progress in development, because I have very good relationships and discussions with my colleagues from different countries, although I haven't seen it with my own eyes.

AAG: One of the responses that we had online was the question, "with nearly a decade of experience, why haven't we been able to see videos or photos of your experiments up until now?"

Podkletnov: Well first of all, when we began those experiments, in Tampere in the early 90's, it just wasn't common practice to make videos or photos of the equipment or of the experiment. I know that it's typical in the United States, but here in Europe it's different...and the same thing goes for Russia, especially with the last experiment in the Moscow Chemical Research Center, because the whole center is a very secure facility and some of the research laboratories are closed to the general public. In our case, nothing was secret, but it was a dangerous environment because we use high-voltages, so it's a closed lab. We have special signs on the walls of the laboratory which do not allow us to make any photos. It's an accepted, established policy at this scientific research center, and I didn't want to break the rules.

AAG: Well, in light of the publicity that you've had recently, have you given thought to doing any photos or video in the near future?

Podkletnov: I've discussed this possibility with the administration and they think it might be possible, but at present we don't have any photos or video to share with you.

AAG: OK – well, I look forward to hopefully seeing some in the future if it turns out that it's possible. To move along, have you been able to obtain funding from government or private interests? Has there been a fair amount of interest that's come forward and tried to provide funding for your experiments?

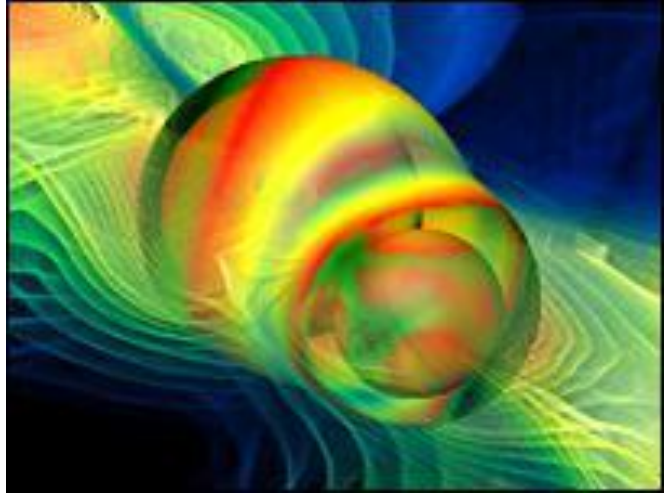


Project Delta-G: The now-defunct NASA group tasked with examining superconductive gravity-coupling.

Podkletnov: There has been some interest from the private sector, because by policy the government does all of the research into gravity and experimental gravity. This type of research is not popular, so we don't get much money from the government. Of course, we use the right installations at the technological center. There is some interest in general all over the world – like the United States and Great Britain, but we didn't get any funding from the government. We get rather small funding from the private sector, but our plans are really amazing and we need considerable funding. So this topic of gravity is a bit unusual, and we need some exotic materials...we need special installations, we need cryogenic systems, we need the help of top people who are qualified in their own areas, and these all cost a lot.

AAG: Just to wrap things up, because we're almost out of time, again it sounds like you're getting amazing results – you're able to put holes through concrete and bend metals with this at 5 million volts – these are remarkable results. Is there anything you'd like to say in close?

Podkletnov: I don't think that these results are remarkable in general. This subject called experimental gravity research has a very big potential, and if we compare how complicated this problem is to the problem of, let's say, nuclear explosives, I think that gravity research is much more complicated. But even if we speak about nuclear power, there was a period in the United States when everybody was interested, and the military and people wanted to make some research, and the government was interested. Then people came and said, "could you please make a small explosion, and then we will give you money for a big one?"...but it's



Gravity-Wave: The core of a gravity-wave event as predicted by Dr. Robert Baker's HFGW

impossible to make a small nuclear explosion. The same thing refers to gravity – it's an enormous problem, and we can't get much if we don't have an organized approach as it was in the nuclear program for example in the United States. Only combining the knowledge of different fields, and of different physicists, chemists, and materials scientists & theoretical physicists – only through them working together can we make a breakthrough in this field, because it's very, very serious research.

Dr. Evgeny is a research scientist living in Finland, with an impressive body of experimental research relating to EM/gravitational coupling in superconductive materials. His published abstracts about the impulse generator experiment are online at: [Investigation of HV discharges through large ceramic superconducting electrodes](#), [Superconductor Impulse Gravity Generator](#)

Impulse Gravity Generator Based on Charged Y Ba₂Cu₃O_{7-y} Superconductor with Composite Crystal Structure

Evgeny Podkletnov¹, Giovanni Modanese²

¹ Moscow Chemical Scientific Research Centre
113452 Moscow - Russia
E-mail: epodkletnov@hotmail.com

² California Institute for Physics and Astrophysics
366 Cambridge Ave., Palo Alto, CA
94306 and
University of Bolzano { Industrial Engineering
Via Sernesi 1, 39100 Bolzano, Italy
E-mail: giovanni.modanese@unibz.it

Abstract

The detection of apparent anomalous forces in the vicinity of high- T_c superconductors under non equilibrium conditions has stimulated an experimental research in which the operating parameters of the experiment have been pushed to values higher than those employed in previous attempts. The results confirm the existence of an unexpected physical interaction. An apparatus has been constructed and tested in which the superconductor is subjected to peak currents in excess of 10^4 A, surface potentials in excess of 1 MV, trapped magnetic field up to 1 T, and temperature down to 40 K. In order to produce the required currents a high voltage discharge technique has been employed. Discharges originating from a superconducting ceramic electrode are accompanied by the emission of radiation which propagates in a focused beam without noticeable attenuation through different materials and exerts a short repulsive force on small movable objects along the propagation axis. Within the measurement error (5 to 7 %) the impulse is proportional to the mass of the objects and independent on their composition. It therefore resembles a gravitational impulse. The observed phenomenon appears to be absolutely new and unprecedented in the literature. It cannot be understood in the framework of general relativity. A theory is proposed which combines a quantum gravity approach with anomalous vacuum fluctuations.

Contents

1 Introduction	2
2 Experimental	2
2.1 General description of the installation	2
2.2 Superconducting emitter, fabrication methods	4
2.3 Organization of the discharge and measurements of the effect.	6

3 Results	7
4 Discussion	10
4.1 A possible theoretical explanation. Basic concepts.	12
4.2 Possible interpretation of the gravitational-like impulse at the discharge . .	19
4.3 Known effects which could be connected to the observed phenomenon. . . .	21
5 Conclusions	26

1 Introduction

Experiments showing possible anomalous forces between high- T_c ceramic superconductors under non equilibrium conditions and test objects have been reported by several investigators since 1992 [1, 2, 3, 4, 5]. The observed phenomenology was difficult to explain and has been attributed to a so called "gravity modification", because the reported effects mimic well the properties of the gravitational interaction, although their nature has never been clearly understood. In fact several alternative explanations of these results have been proposed [6, 7, 8, 9, 42] in the attempt to bring the observed anomalies into the realm of known effects.

Because of the great importance of any possible technical application of the reported effects, research activities have started in many laboratories since the first observation of the phenomenon [1]. Our recent research work focused on the improvement of the structure of the high- T_c ceramic superconductors which have demonstrated capabilities of creating anomalous forces. Moreover a high-voltage discharge apparatus has been designed and constructed in order to easily reach those non equilibrium electromagnetic conditions that seem required to produce the force effects in HTCS.

The results described in this report should be regarded as preliminary. An improved version of the experiment is currently being planned. Nevertheless, the body of results, as well as the complexity of the experimental procedures and of the theoretical interpretation are such that a detailed description and discussion could not be further delayed. All measurements were done by E. Podkletnov in Moscow, while G. Modanese provided theoretical advice.

2 Experimental

2.1 General description of the installation

The initial variant of the experimental set-up was based on a high-voltage generator placed in a closed cylinder chamber with a controlled gas atmosphere, as shown in Fig. 1. Two metal spheres inside the chamber were supported by hollow ceramic insulators and had electrical connections that allowed to organize a discharge between them, with voltage

up to 500 kV . One of the spheres had a thin superconducting coating of $\text{Y Ba}_2\text{Cu}_3\text{O}_7$ obtained by plasma spraying using a "Plasmatech 3000S" installation. This sphere could be charged to high voltage using a high voltage generator similar to that of Van de Graaf. The second sphere could be moved along the axis of the chamber, the distance between the spheres varying from 250 to 2000 mm. Spheres with a diameter from 250 to 500 mm were used in the experiment. It was possible to fill the chamber with helium vapours or to create rough vacuum using a rotary pump. The walls of the chamber were made of non-conducting plastic composite material, with a big quartz glass window along one of the walls which allowed to observe the shape, the trajectory and the colour of the discharge. In order to protect the environment and the computer network from static electricity and powerful electromagnetic pulses, the chamber could be shielded by a Faraday cage with cell dimensions of 2:0 2:0 cm and a rubber-plastic 1m material absorbing ultra high frequency (UHF) radiation.

The superconducting sphere was kept at a temperature between 40 and 80 K, which was achieved by injecting liquid helium or liquid nitrogen through a quartz tube inside the volume of the superconducting sphere before the charging began. The inside volume of the chamber was evacuated or filled with helium in order to avoid the condensation of moisture and different gases on the superconducting sphere. The temperature of the superconductor was measured using a standard thermocouple for low temperature measurements and was typically around 55-60 K. Given the good heat conductivity of the superconductor, we estimated that the temperature difference in the ceramic did not exceed 1 K.

An improved variant of the discharge chamber is shown in Fig. 2. The charged electrode was changed to a toroid attached to a metal plate and a superconducting emitter which had the shape of a disk with round corners. The non-superconducting part of the emitter was fixed to a metal plate using metal Indium or Wood's metal, the superconducting part of the emitter faced the opposite electrode. The second electrode was a metal toroid of smaller diameter, connected to a target. The target was a metal disk with the diameter of 100 mm and the height of 15 mm. The target was attached to a metal plate welded to the toroid.

This improved design of the generator was able to create a well-formed discharge between the emitter and the target, still the trajectory was not always repeatable and it was difficult to maintain constant values of current and voltage. The chamber was also not rigid enough to obtain high vacuum and some moisture was condensing on the emitter, damaging the superconducting material and affecting the discharge characteristics. The large distance between the electrodes also caused considerable dissipation of energy during discharge. In order to improve the efficiency of operation, the measuring system and the reproducibility of the discharge, an entirely new design of the vacuum chamber and the charging system was created.

The final variant of the discharge chamber is presented in Fig. 3 (the apparatus is shown in a vertical position though actually it is situated parallel to the floor). This set-up allowed to reduce the dimensions of the installation and to increase the efficiency of the process. The chamber has the form of a cylinder with the approximate diameter of 1 m and the length of 1.5 m and is made of quartz glass. The chamber has two connecting sections with hinges which allow to change the emitter easily. The design permits to

create high vacuum inside or to fill the whole volume with any gas that is required. The distance of the discharge has been decreased considerably giving the possibility to reduce energy dissipation and to organize the discharge in a better way. The distance between the electrodes can vary from 0.15 to 0.40 m in order to find the optimum length for each type of the emitter.

The discharge can be concentrated on a smaller target area using a big solenoid with the diameter of 1.05 m that is wound around the chamber using copper wire with the diameter of 0.5 cm. The magnetic flux density is 0.9 T. A small solenoid is also wound around the emitter (Fig. 3) so that the magnetic field can be frozen inside a superconductor when it is cooled down below the critical temperature.

The refrigeration system for the superconducting emitter provides a sufficient amount of liquid nitrogen or liquid helium for the long-term operation and the losses of gas due to evaporation are minimized because of the high vacuum inside the chamber and thus of a better thermal insulation.

A photodiode is placed on the transparent wall of the chamber and is connected to an oscilloscope, in order to provide information on the light parameters of the discharge. Given the low pressure and the high applied voltage, emission of X-rays from the metallic electrode cannot be excluded, but the short duration of the discharge makes their detection difficult. Use of a Geiger counter and of X-rays sensitive photographic plates did not yield any clear signature of X-rays.

A precise measurement of the voltage of the discharge is achieved using a capacitive sensor that is connected to an oscilloscope with a memory option as shown in the upper part of Fig. 3. Electrical current measurements are carried out using a Rogowski belt, which is a single loop of a coaxial cable placed around the target electrode and connected to the oscilloscope.

The old fashioned Van de Graaf generator used in the previous stage of this work was replaced by a high voltage pulse generator as shown in Fig. 4. This pulse generator is executed according to the scheme of Arkadjev-Marx and consists of twenty capacitors (25 nF each) connected in parallel and charged to a voltage up to 50-100 kV using a high voltage transformer and a diode bridge. The capacitors are separated by resistive elements of about 100 k Ω . The scheme allows to charge the capacitors up to the needed voltage and then to change the connection from a parallel to a serial one. The required voltage is achieved by changing the length of the air gap between the contact spheres C and D. A syncro pulse is then sent to the contacts C and D which causes an overall discharge and serial connection of the capacitors and provides a powerful impulse up to 2 MV which is sent to the discharge chamber. The use of such an impulse generator allows for a precisely controlled voltage, much shorter charging time and good reproducibility of the process.

2.2 Superconducting emitter, fabrication methods

The superconducting emitter has the shape of a disk with the diameter of 80-120 mm and the thickness of 7-15 mm. This disk consists of two layers: a superconducting layer with chemical composition $YBa_2Cu_3O_{7-y}$ (containing small amounts of Ce and Ag) and

a normal conducting layer with chemical composition $Y_{1-x}Re_xBa_2Cu_3O_{7-y}$, where Re represents Ce, Pr, Sm, Pm, Tb or other rare earth elements. The materials of both layers were synthesized using a solid state reaction under low oxygen pressure (stage 1), then the powder was subjected to a melt texture growth (MTG) procedure (stage 2). Dense material after MTG was crushed, ground and put through sieves in order to separate the particles with the required size. A bi-layered disk was prepared by powder compaction in a stainless steel die and sintering using seeded oxygen controlled melt texture growth (OCMTG) (stage 3). For the emitters with the diameter of 120 mm usual sintering was applied instead of seeded OCMTG (stage 4). After mechanical treatment the ceramic emitter was attached to the surface of the cooling tank in the discharge chamber using Indium based alloy.

Stage 1 - Micron-size powders of Y_2O_3 and CuO , $BaCO_3$ were mixed in alcohol for 2 hours, then dried and put in zirconia boats in a tube furnace for heat treatment. The mixture of powders was heated to $830^\circ C$ and kept at this temperature for 8 hours at oxygen partial pressure of $2 \cdot 10^{-2}$ Pa (or 2-4 mBar) according to [10, 11]. The material of the normal conducting layer was sintered in a similar way.

Stage 2 - Micron-size powder of $YBa_2Cu_3O_x$ was pressed into pellets using a metal die and low pressure. The pellets were heated in air to $1050^\circ C$ ($100^\circ C$ per hour) then cooled to $1010^\circ C$ ($10^\circ C$ per hour) then cooled to $960^\circ C$ ($2^\circ C$ per hour) then cooled to room temperature ($100^\circ C$ per hour) according to a standard MTG technique [12, 13]. The quantity of 211 phase during heating was considerably reduced and the temperature was changed correspondingly. $ReBa_2Cu_3O_{7-x}$ was also prepared using MTG, but the temperature was slightly changed according to the properties of the corresponding rare earth oxide.

Stage 3 - Bulk material after MTG processing was crushed and ground in a ball mill. The particles with the size less than 30 μm were used for both layers of the ceramic disk. The particles were mixed with polyvinyl alcohol binder. The material of the first layer was put into a die, pressed and then the material of the second layer was placed over it. The disk was formed using a pressure of 50 MPa. The single crystal seeds of Sm123 (about $1 mm^3$) were placed on the surface of the bi-layered disk so that the distance between them was about 15 mm and the disk was subjected to a OCMTG treatment in 1% oxygen atmosphere. The growth kinetics of YBCO superconductor were controlled during isothermal melt texturing. A modified melt texturing process was applied, where instead of slow cooling following melting, isothermal hold was employed in the temperature range where the growth is isotropic. By this modification, the time required to texture the disk was reduced to 7 hours which is about 10 times faster than a typical slow cooling melt texturing process. The crystallization depth was controlled by applying the corresponding temperature and time parameters. Cubic Sm123 seeds were obtained using the nucleation and growth procedure as described in [16, 17]. A thin layer of the material was removed from the top surface of the disk to a depth of 0.3 mm and the edges of the upper surface were rounded using diamond tools.

Stage 4 - For the emitters with the diameter of 120 mm it is technically difficult to apply seeded MTG method, therefore normal sintering was carried out. Bulk material after MTG processing (after stage 2) was crushed and sieved and the following size particles

were used for both layers of the ceramic disk, the amount is given in weight percent:

500-400 m	50-60%
120-60 m	25-35%
< 20 m	15-25%

The particles were mixed according to the ratio listed above using polyvinyl alcohol as a binder. The material of the first layer was put into a die, pressed and the material of the second layer was placed over it. The disk was formed using the pressure of 120 MPa and sintered in oxygen at 930 °C for 12 hours followed by slow cooling down to room temperature. The edges of the upper surface were rounded using diamond tools.

X-ray diffraction, transition temperature, electrical conductivity and critical current density were measured for both layers of various emitters using standard techniques.

2.3 Organization of the discharge and measurements of the effect.

The discharge chamber is evacuated to 1.0 Pa using first a rotary pump and then a cryogenic pump. When this level of vacuum is reached, liquid nitrogen is pumped into a tank inside the chamber that contacts the superconducting emitter. Simultaneously a current is sent to the solenoid that is wound around the emitter, in order to create a magnetic flux inside the superconducting ceramic disk. When the temperature of the disk falls below the transition temperature (usually 90 K) the solenoid is switched off. The experiment can be carried out at liquid nitrogen temperatures or at liquid helium temperatures. If low temperatures are required, the tank is filled with liquid helium and in that case the temperature of the emitter reaches 40-50 K.

The high voltage pulse generator is switched on and the capacitors are charged to the required voltage. It takes about 120 s to charge the capacitors. A syncro pulse is sent to a pair of small metal spheres marked as C and D in Fig. 5. A discharge with voltage up to 2 MV occurs between the emitter and the target. Half a second before the discharge, a short pulse of direct current is sent for 1 s to the big solenoid that is wound around the chamber, in order to concentrate the discharge and to direct it to the same area on the target electrode. This pulse lasts for only 1 s not to cause the overheating of the big solenoid.

The effects are measured along the projection of the axis line which connects the center of the emitter with the center of the target. Laser pointers were used to define the projection of the axis line and impulse sensitive devices were situated at the distance of 6 m and 150 m from the installation (in another building across the area).

Normal pendulums were used to measure the pulses of gravity radiation coming from the emitter. The pendulums consisted of spheres of different materials hanging on cotton strings inside glass cylinders under vacuum. One end of the string was fixed to the upper cap of the cylinder, the other one was connected to a sphere. The spheres had typically a diameter from 10 to 25 mm and had a small pointer in the bottom part. A ruler was placed in the bottom part of the cylinder, 2 mm lower than the pointer. The deflection

was observed visually using a ruler inside the cylinder (Fig. 5). The length of the string was typically 800 mm, though we also used a string 500 mm long. Various materials were used as spheres in the pendulum: metal, glass, ceramics, wood, rubber, plastic. The tests were carried out when the installation was covered with a Faraday cage and UHF radiation absorbing material and also without them. The installation was separated from the impulse measuring devices situated 6 m away by a brick wall of 0.3 m thickness and a list of steel with the dimensions 1 m 1:2 m 0:025 m. The measuring systems that were situated 150 m away were additionally shielded by a brick wall of 0.8 m thickness.

In order to define some other characteristics of the gravity impulse - in particular its frequency spectrum - a condenser microphone was placed along the impact line just after the glass cylinders. The microphone was connected to a computer and placed in a plastic spherical box filled with porous rubber. The microphone was first oriented with a membrane facing the direction of the discharge, then it was turned 22.5 degrees to the left, then 45 degrees to the left, then 67.5 degrees and finally 90 degrees. Several discharges were recorded in all these positions at equal discharge voltage.

3 Results

Several unexpected phenomena were observed during the experiments. The discharge in the installation corresponding to the initial set-up (Fig. 1) at room temperature in the voltage range from 100 kV to 450 kV was similar to a discharge with non-coated metal spheres and consisted of a single spark between the closest points on the spheres. When the superconductor coated sphere was cooled down below the transition temperature, the shape of the discharge changed in such a way that it did not form a direct spark between two spheres, but the sparks appeared from many points on the superconducting sphere and then moved to the corresponding electrode. When the voltage was over 500 kV the discharge at the initial stage had a tendency to cause some glow with the shape of a hemisphere. This glow separated from the sphere and then broke into multiple sparks which combined into more narrow bundle and finally hit the surface of the target electrode.

Repeated discharges at high voltages caused damage to the superconducting coating and partial separation of the ceramic material from the metal sphere, as the refrigeration system was not efficient enough. Also the direction of the discharge was not always repeatable. The experiments were continued with the improved variant of the installation as shown in Fig. 2 and then with the final variant of the installation as shown in Fig. 3. This new configuration allowed to increase the reproducibility of the discharge and the superconducting emitter was not damaged with high voltage. With voltage lower than 400 kV the discharge had the shape of a spark but when the voltage was increased to 500 kV the front of the moving discharge became flat with diameter corresponding to that of the emitter. This flat glowing discharge separated from the emitter and moved to the target electrode with great speed. The whole time of the discharge as defined by the photo diode was between 10^{-5} and 10^{-4} s. The peak value of the current at the discharge for the maximum voltage ($2 \cdot 10^6$ V) is of the order of 10^4 A.

It was found that high voltages discharges organized through the superconducting

Table 1: Emitter N. 2. Influence of high voltage discharges on the deflection of the pendulum. Experimental data are the average of 12 measurements. The standard deviation of the single data is between 5 and 7 %.

Voltage (kV)	l (mm)	h (mm)	Estimated E (J 10^{-4})
500	56.5	2.0	3.6
750	91.3	5.2	9.5
1000	110.4	7.7	13.9
1250	123.0	9.5	17.3
1500	131.6	10.9	19.8
1750	137.6	11.9	21.7
2000	142.0	12.7	23.1

emitter kept at the temperature of 50-70 K were accompanied by a very short pulse of radiation coming from the superconductor and propagating along the axis line connecting the center of the emitter and the center of the target electrode in the same direction as the discharge. The radiation appeared to penetrate through different bodies without any noticeable loss of energy. It acted on small interposed mobile objects like a repulsive force field, with a force proportional to the mass of the objects. As the properties of this radiation are similar to the properties of the gravity force, the observed phenomenon was called a gravity impulse.

In order to investigate the interaction of this gravity impulse with various materials, several tests were carried out, with pendulums and microphones, as described in the experimental part. The deflection of the pendulum was observed visually (see Fig. 5) and the corresponding l value was measured as a function of the discharge voltage. The correlation between the discharge voltage and the corresponding deflection of the pendulum as measured for two different emitters is listed in Tables 1, 2. Each value of l that is given in the table represents the average figure calculated from 12 discharges. A rubber sphere with a weight of 18.5 grams was used as material of the pendulum for the data listed in Tables 1, 2. The deflection caused an alteration in the potential energy of the pendulum which was proportional to h as shown in the table. A graphic illustration of this dependence for two different emitters is given in Fig. 6.

Both emitters, N. 1 and N. 2, were manufactured using the same OCMTG technology, but the thickness of the superconducting layer was equal to 4 mm for the emitter N. 1 and 8 mm for the emitter N. 2. Emitter N. 2 could be magnetized to a much higher value. The thickness of the normal conducting layer has a smaller influence on the force of the gravity impulse, but for better results the thickness should be bigger than 5 mm.

It was found that the force of the impact on pendulums made of different materials does not depend on the material but is only proportional to the mass of the sample. Pendulums of different mass demonstrated equal deflection at constant voltage. This was proved by a large number of measurements using spherical samples of different mass and

Table 2: Same for Emitter N. 1.

	Voltage (kV)	l (mm)	h (mm)	Estimated E (J 10^{-4})
500	40.0	1.0		1.8
750	70.9	3.2		5.7
1000	85.3	4.6		8.3
1250	94.6	5.6		10.2
1500	100.8	6.4		11.6
1750	104.7	6.9		12.5
2000	107.1	7.2		13.1

diameter. The range of the employed test masses was between 10 and 50 grams. It was also found that there exist certain deviations in the force of the gravity impulse within the area of the projection of the emitter. These deviations (up to 12-15% max) were found to be connected with the inhomogenities of the emitter material and various imperfections of the crystals of the ceramic superconductor, and with the thickness of the interface between superconducting and normal conducting layers.

Measurements of the impulse taken at close distance (3-6 m) from the installation and at the distance of 150 m gave identical results, within the experimental errors. As these two points of measurements were separated by a thick brick wall and by air, it is possible to admit that the gravity impulse was not absorbed by the media, or the losses were negligible.

The force "beam" obtained with the latest experimental set-up does not appear to diverge and its borders are clear-cut. However, considerable efforts were necessary in order to concentrate the radiation and reach a good reproducibility. As mentioned above, the direction emission always coincides with the direction of the discharge. In the initial experiments (with the Van den Graaf generator), the direction of the beam varied, depending on the direction of the discharge, as the sparks moved to different points on the superconducting sphere. Later it was found that the magnetic field created by the solenoid wound around the chamber is able to concentrate the discharge and to direct it to the same area on the superconducting electrode.

The bi-layered emitters used in this experiment were mainly of two types. The first one was obtained after Stage 3 and had a structure typical for multiple-domain levitators with well crystallized and oriented grains of the superconducting layer. The second type was made by the material obtained after Stage 4 and consisted of densely packed non oriented polycrystalline structure in both layers. The superconducting layer in both types of emitters consisted of $YBa_2Cu_3O_{7-y}$ orthorhombic superconductor with lattice parameters $a = 3.89\text{\AA}$, $b = 11.69\text{\AA}$, $c = 3.82\text{\AA}$. The addition of small amounts of CeO_2 led to an improvement in the magnetic flux pinning properties of the Y123 compound. The emitter obtained by seeded MTG process had a superconducting layer with a maximum trapped field of 0.5 T at 77 K and a critical current density in excess of $5 \cdot 10^4 \text{ A/cm}^2$. The transition temperature varied from 87 to 90 K with a transition width of about 2 degrees. The normal conducting layer had crystal lattice parameters close to those of the super-

conductor: $a = 3.88\text{\AA}$, $b = 11.79\text{\AA}$, $c = 3.82\text{\AA}$. Both layers demonstrated high electrical conductivity (over 1.5 Sm) at room temperature and the $\text{Y}_{1-x}\text{Re}_x\text{Ba}_2\text{Cu}_3\text{O}_{7-y}$ layer was a normal conductor above 20 K .

In general the emitters obtained by seeded OCMTG were much more efficient than the sintered bi-layered emitters and allowed to obtain a much stronger radiation impulse, contained by the projection of the emitter. The sintered bi-layered emitters had much lower values of the trapped magnetic field and this yielded bigger energy dissipation and a weaker gravity impulse. The only advantage of the sintered emitters is that a weak impulse effect is always present, probably because the diffusion between the layers is limited. The emitters with oriented crystal structure (after seeded MTG) can be easily spoiled if the interface thickness between the two layers reaches a certain value, therefore the temperature and time parameters should be monitored carefully in order to limit the interaction between the two layers. It was found that the seeded crystal growth should be stopped before it reaches the interface region.

It was also found that the gravity impulse was to some extent proportional to the magnetic field inside the superconductor, which was created using a small solenoid during cooling down to liquid nitrogen temperature. Therefore, at recent stages of the experiment the solenoid was replaced by a powerful permanent NdFeB magnet (50 MOe) with a diameter corresponding to the diameter of the emitter and a thickness of 20 mm . This disk-shaped magnet was attached with one surface to the cooling tank and with another surface to the ceramic emitter.

The response recorded by the microphone has the typical behavior of an ideal pulse filtered by the impulse response of a physical low pass system with a bandwidth of about 16 kHz , attributed to the microphone (Fig. 7). In spite of the filtering, the relative energy of the pulses can be measured as a function of the angle of the normal to the diaphragm respect to the axis of propagation of the force.

Relative pulse amplitude with energies averaged over four pulses per angle are shown in Fig. 8 and are in agreement with a possible manifestation of a vector force acting directly on the membrane. No signal has been detected outside the impact region.

4 Discussion

(a) Capacitance of the emitter. Current at the discharge.

High voltage discharges like those described in Sections 2, 3 are well known in the literature. They do not require pre-ionisation, provided the electric field between the electrodes is sufficient to cause avalanche ionisation. However, the presence of a superconducting electrode causes some difference in the form and colour of the crown and of the sparkle, with respect to discharges between normal electrodes.

We recall that for the maximum voltage ($2 \cdot 10^6\text{ V}$) the peak value of the current is of the order of 10^4 A , and the duration of the discharge varies between 10^{-5} and 10^{-4} s . This implies a total negative charge Q on the emitter, just before the discharge, up to 0.1 C . The associated electrostatic energy is $U = QV = 2 \cdot 10^5\text{ J}$.

If the emitter was made of a normal conductor, its capacitance could be at most 10^{-10} F (for an estimate one can consider the capacitance of a sphere, namely $C = 10^{-10} R$ in SI units, where R is the radius). The above value for Q implies a much higher effective capacitance, of the order of 10^{-7} F.

During the discharge an intense super-current flows from the superconducting electrode towards the ionised gas. After the superconducting charge carriers leave the negative electrode, pairs are broken and electrons are captured by the helium ions which are striking the electrode. We thus have a peculiar kind of superconductor-normal junction. Another junction is that between the superconducting emitter and the normal metallic plate.

From the theoretical point of view, these junctions can be described by Ginzburg-Landau models without specific reference to the microscopic theory. A typical time scale for the time-dependent Ginzburg-Landau equation in YBCO is of the order of 10^{-8} s [42], much smaller than the discharge time. This suggests that a quasi-stationary approximation could be adequate. The situation is however complicated by the following circumstances:

(1) In anisotropic materials like HTCs the Ginzburg-Landau equation involves an order parameter with non-trivial symmetry and the pairs are thought to possess intrinsic angular momentum.

(2) The transport current is very intense. In type-II superconductors, transport currents are associated to non-reversible displacement of flux lines, and this effect in turn depends strongly on the pinning properties of the material.

(3) The emitter is subjected to a strong external magnetic field during the discharge.

More efforts are therefore necessary, both on the experimental and theoretical side, for a complete understanding of the state of the superconducting emitter during the discharge.

(b) Evidence of the gravitational-like nature of the effect.

The gravitational-like nature of the effect is best demonstrated by its independence on the mass and composition of the targets (see Section 3). We are aware, of course, that gravitational interactions of this kind are absolutely unusual (see Sections 4.1, 4.3). For this reason, several details of the experimental apparatus were designed with the explicit purpose of reducing spurious effects like mechanical and acoustic vibrations much below the magnitude order of the observed anomalous forces.

Indirect evidence for a gravitational effect comes from the fact that any kind of electromagnetic shielding is ineffective. Note that if one can explain in some way the anomalous generation of a gravitational field in the superconductor, its undisturbed propagation follows as a well-known property of gravity (see Section 4.2). Indirect support for the gravitational hypothesis also comes from the partial similarity of this apparatus to that employed by Podkletnov for the stationary weak gravitational shielding experiment [1].

If the effect is truly gravitational, then the acceleration of any test body on which the impulse acts should be in principle independent on the mass of the body. Suppose that l is the length of a detection pendulum and g is the local gravitational acceleration. Let d be the half-amplitude of the oscillation. Let t be the duration of the impulse, and F its strength. F has the dimensions of an acceleration (m/s^2) and can be compared with g .

One easily computes that the product of the strength of the impulse by its duration is

$$F t = \frac{r}{2gl[11 - (d/l)^2]} \quad (1)$$

If $d \ll l$, this formula can be simplified, and we have approximately $F t \approx \frac{r}{2gl} d = 2 d = T$, where T is the period of the pendulum. With the data of Table 1, taking $t = 10^{-4}$ s, one finds $F \approx 10^3 g$.

Here, however, we encounter a conceptual difficulty. Suppose to place on the trajectory of the beam a very massive pendulum (say, 10^3 Kg). If the effect is gravitational, then the acceleration of a test mass should not depend on its mass. However, it is clear that in order to give this mass the same oscillation amplitude of the small masses employed in the experiment, a huge energy amount is necessary, which cannot be provided by the device. Therefore the effect would seem to violate the equivalence principle. Considering the back-reaction is probably necessary, namely the fact that the test mass exerts a reaction on the source of the impulse. This reaction is negligible as long as we use small test masses.

(c) Anomalous features of the observed "radiation".

Independently from any interpretation, the abnormal character of this radiation appears immediately clear. It appears to propagate through walls and metal plates without noticeable absorption, but this is not due to a weak coupling with matter, because the radiation acts with significant strength on the test masses free to move. Furthermore, this radiation conveys an impulse which is certainly not related to the carried energy by the usual dispersion relation $E = pc$. A corresponding energy transfer to the test masses is not in fact observed (unless one admits perfect reflection, which seems however very unlikely).

The denomination "radiation" is actually unsuitable, and one could possibly envisage an unknown quasi-static force field. In this way one could explain why an impulse is transmitted to the test masses. However, it is hard to understand how such a field could be so well focused.

4.1 A possible theoretical explanation. Basic concepts.

The following Sections contain an informal introduction to a theoretical model originally developed by one of the authors [18, 19, 20, 21, 22] in order to explain the weak gravitational shielding effect by HTC superconductors [1, 2]. We suggest that this theory may be a starting point for the explanation of the impulsive gravitational-like forces described in the present paper.

The quantum properties of the gravitational field play an essential role in this model. These properties are not adequately known yet, therefore the proposed model is still in a preliminary development phase and its predictive capabilities are quite limited. Its primary merit is to envisage a new dynamic mechanism which could account for the effect. However, a full theory which justifies the model does not exist so far. This should be, in fact, a theory of the interaction between gravity (including its quantum aspects), and a particular state of matter - that of a HTC superconductor - which in turn is not completely known.

The glossary below ¹ collects some keywords and their equivalent, also for a better orientation in the cited works.

(a) Weakness of the standard coupling with gravity. Anomalous coupling.

The standard coupling of matter to gravity is obtained from the Einstein equations by including the material part of the system into the energy-impulse tensor. Since the coupling constant is $G=c^4$, very large amounts of matter/energy, or at least large densities, are always necessary in order to obtain gravitational effects of some importance. This holds also at the quantum level, in weak field approximation. It is possible to quantize the gravitational field by introducing quantum fluctuations with respect to a classical background, and then calculate the graviton emission probabilities associated to transitions in atomic systems. These always turn out to be extremely small, still because of the weakness of the coupling.

What we proved in our cited works is that a peculiar "anomalous" coupling mechanism exists, between gravity and matter in a macroscopic quantum state. In this state matter is described by a collective wave function. Also in this state the energy-impulse of matter couples to the gravitational field in the standard way prescribed by the equivalence principle. However, the new idea is that besides this standard coupling there is another effect, due to the interference of the Lagrangian L of coherent matter with the "natural" vacuum energy term $=8G$ which is present in the Einstein equations. The two quantities have in fact the same tensorial form but possibly different sign, and it turns out that their interference can lead to a dramatic enhancement of vacuum fluctuations.

(b) Contribution of a quantum condensate to the vacuum energy density.

It is well known that the "natural" vacuum energy, or cosmological term, is very small. Until recently, it was thought to be exactly null. The most recent observations give a value different from zero, but in any case very tiny [23, 47], of the order of $0.1 J=m^3$. This is usually supposed to be relevant at cosmological level, in determining the curvature and expansion rate of the universe on very large scales.

The observed value can be regarded as the residual of a complex interplay, in a still unknown high energy sector of particle physics, between positive and negative vacuum energy densities. According to [24], the observed residual should also be scale-dependent and this dependence could appear most clearly at length scales corresponding to the mass of the lightest particles like neutrinos or unidentified scalars.

¹**Cosmological term = vacuum energy density:** see (b).

Lagrangian L = action density. Minimization of the action of a system gives its dynamical equations.

Quantum condensate in a superconductor: ensemble of the Cooper pairs, with collective wave function

ψ (also called an "order parameter") supposed to obey the Ginzburg-Landau (GL) equation. In the non-relativistic limit, the Lagrangian density of the condensate is just the opposite of the GL free energy density.

Zero-modes of the Einstein action = gravitational dipolar fluctuations: see (c).

Critical region: region of the condensate with positive Lagrangian density. According to the GL theory, it can only exist for constant solutions of the GL equation or in the neighbourhood of a local relative maximum of the Cooper pair density j_{GL}^2 . See (f).

Noise source = density matrix: a formal way to express the fact that inside a critical region the gravitational field undergoes strong dipolar fluctuations and therefore takes on at random values h^2_i with probability i . See (h), (i).

In certain conditions, the action density of a Bose condensate in condensed matter can be greater than the cosmological term, but it is nonetheless very small. Its effect on the local space curvature is absolutely negligible.

(c) The gravitational zero modes and the polarization of the gravitational vacuum.

Why so do we think that the interference of these two terms, which are in any case very small, can lead to some observable gravitational effect? Because we proved the existence of gravitational field configurations in vacuum, for which the value of the pure Einstein action (without the cosmological term) is exactly null, like for flat space. We called these configurations "zero modes of the Einstein action". At the quantum level, where fluctuations are admitted with respect to flat space, they are free to grow unrestrained. In a certain sense, the quantum space-time is unstable and has a natural tendency not to stay in the flat state, but to fall into these configurations, with a definite probability. They are virtual configurations, in the sense that they are permitted in the Feynman integral describing the quantum theory. In the Feynman integral all the possible configurations are admitted - not only those satisfying the field equations - each weighed with probability equal to the exponential of its action divided by $\hbar$. All these configurations (fluctuations) take part in defining the state of the system.

The zero-modes of the Einstein action are in all the same as fields produced by mass dipoles. In nature, mass dipoles do not exist as real sources. Nevertheless, the dipolar fluctuations mathematically have such a form. Being vacuum fluctuations, they are invariant under translations and Lorentz transformations, they are homogeneously allocated in space and at all length scales. That is, the dipolar fluctuations correspond to the fields produced by dipoles of various sizes, distributed in a uniform way. They can only show their presence if, in some way, their homogeneity and uniformity are broken. We are in presence of an analogue of the vacuum polarization in quantum electrodynamics. In that case, virtual couples of electrons/positrons pop up in the vacuum, and then quickly annihilate, generating uniform fluctuations. It is well known that these virtual processes must be taken into account, because they affect, for instance, the bare charge of the particles and their couplings. However, quantum corrections are, as a rule, very small in quantum electrodynamics.

It is important to be aware that the gravitational dipolar fluctuations we are talking about are neither the ordinary fluctuations of perturbation theory nor the well known "spacetime foam" fluctuations, which appear in quantum gravity at very short distances. Their nature is completely different. Although their intensity can be very large, they have null action, thanks to the compensation of positive and negative curvature between adjacent zones of space-time. The dipolar fluctuations are not zero-modes of the Lagrangian, but of the action. Their existence is possible thanks to the fact that the gravitational Lagrangian is not defined positive, unlike the Lagrangian of electromagnetic and gauge fields.

(d) The vacuum energy cuts the gravitational zero-modes to a certain level.

Let us go back to the cosmological term. One finds that it is related to the dipolar fluctuations, because it sets an upper limit on their amplitude. The contribution of a

dipolar fluctuation to the cosmological term is typically of the form [21]

$$S = -Mr^2Q \quad (2)$$

where natural units are used ($\hbar = c = 1$); t is the duration of the fluctuation, M is the order of magnitude of the virtual $\pm$ masses, r their distance and Q is an adimensional function which depends on the detailed form of the dipole. If $S \ll 1$, then the fluctuation is suppressed.

With an electromagnetic analogy (not to be pushed too far) we could then say that the cosmological term sets the gravitational polarizability of free space. One expects that in a full non-perturbative theory of quantum gravity the bare value of the gravitational constant G should be renormalized by this effect. However, as long as the cosmological term is uniform in space and time, there are no observable consequences. On the other hand, if the vacuum energy density changes locally, this can have observable effects. In particular, if there are positive local contributions which subtract from the natural density, the result can be a local increase in the gravitational polarizability.

(e) The anomalous coupling is only active when the condensate is in certain particular states.

Our model can also explain why only certain superconductors in certain conditions show evidence of anomalous coupling with the gravitational field. The key point is not simply the presence of a quantum condensate, nor the density of this condensate. In fact, if this was the case, anomalous gravitational effects would be observed also with low temperature superconductors, or with superfluids. But even in the static Podkletnov experiment, only in certain conditions observable effects are obtained, and their intensity is variable.

Therefore the presence of the condensate is not sufficient to cause the effect. What are the necessary conditions? The anomalous contribution to the cosmological term is given by the Lagrangian density of the condensate, according to the following equations. Consider a scalar field interacting with gravity (we use units $\hbar = c = 1$; SI units will be restored in eq. (12)). The interaction action is obtained from the energy-momentum tensor:

$$L = \frac{1}{2}(\partial_\mu \phi \partial^\mu \phi - m^2 \phi^2) \quad (3)$$

$$T_{\mu\nu} = \partial_\mu \phi \partial_\nu \phi - \frac{1}{2} g_{\mu\nu} L \quad (4)$$

$$S_{\text{interaction}} = \frac{1}{2} \int d^4x \sqrt{-g} T_{\mu\nu} h^{\mu\nu} \quad (5)$$

To lowest order in h the interaction action can be rewritten as

$$S_{\text{interaction}} = \frac{1}{2} \int d^4x \sqrt{-g} T_{\mu\nu} h^{\mu\nu} \quad (6)$$

On the other hand, the cosmological term is (still to lowest order in h and expanding

$$\sqrt{-g} = 1 + \frac{1}{2} \text{Tr} h + \dots \quad \int d^4x \sqrt{-g} \Lambda = \int d^4x \left(\Lambda + \frac{1}{2} \text{Tr} h \Lambda + \dots \right) \quad (7)$$

Therefore the sum of the two terms can be rewritten as

$$S_{\text{interaction}} + S = \frac{1}{2} \int d^4x \hbar \nabla^2 \phi + \frac{1}{2} \int d^4x \text{Tr} \hbar^2 G_L \quad (8)$$

We see that to leading order the coupling of gravity to gives a typical source term ($\hbar \nabla^2 \phi$) and subtracts from the local density $\hbar^2 G_L(x)$. This separation is arbitrary, but useful and reasonable if the Lagrangian density is such to affect locally the "natural" cosmological term and change the spectrum of gravitational vacuum fluctuations corresponding to virtual mass densities much larger than the real density of .

For example, suppose that represents a condensate with the density of ordinary matter ($\sim 1 \text{ g/cm}^3$). At the scale $r \sim 10^{-4} \text{ cm}$, 10^{-4} s , with the observed value of , the upper bound on the virtual source density is 10^{17} g/cm^3 , which is much larger than the real density. If L is comparable to $\sim 8 G$ in some region, an inhomogeneity in the cut-off mechanism of the dipolar fluctuations will follow, and this effect could exceed by far the effects of the coupling ($\hbar \nabla^2 \phi$) to real matter.

The value of the Lagrangian depends on the state the condensate is in, and more exactly on the macroscopic wave function ϕ_L of the Cooper pairs. The problem of finding the wave function in given experimental conditions is still open. From the wave function one can compute the Lagrangian, and then the local contribution of the superconductor to the vacuum energy, and its ability to produce anomalous gravitational coupling.

(f) L subtracts from only where the density $j \phi_L^2$ has a local maximum.

The Lagrangian L in eq. (3) is the Klein-Gordon Lagrangian which describes a relativistic free scalar field. In order to relate it, in the low energy limit, to the Ginzburg-Landau (GL) free energy of superconductors [25] one makes the standard transformation

$$\phi_{KG}(x) = e^{imt} \phi(x) \quad (9)$$

where m is the Cooper pair mass. Then one turns to the GL wave function by re-normalizing ϕ_{KG} as follows

$$\phi_{KG}(x) = \frac{1}{\sqrt{m}} \phi_{GL}(x) \quad (10)$$

This normalization corresponds to the standard relation $j \phi_{GL}(x)^2 = \rho(x)$, where ρ is the density of Cooper pairs. Finally, the free Lagrangian is generalized by adding a quadratic and a quartic interaction term and the minimal electromagnetic coupling. In this way one finds

$$L = \frac{1}{2m} j^2 (\partial_\mu \phi)^2 + 2eA \cdot j + \frac{1}{2} (\phi^2)^2 \quad (11)$$

This is the Lagrangian density to be inserted into eq. (8) as contribution to the vacuum energy density. It is the opposite of the GL free energy density [?], as expected. For wave functions which satisfy the wave equation derived from (11), the expression of L simplifies to

$$L = \frac{1}{2m} \hbar^2 (\nabla^2 \phi)^2 + \hbar^2 \nabla^2 \phi^2 - m^2 \phi^2 \quad (12)$$

where $\hbar$ has been re-introduced to allow for a better numerical estimate.

We recall [26] that the coefficients depend on the absolute temperature T . The coefficient is always positive and approximately constant near T_c ; is negative for $T < T_c$ and near T_c behaves like $\text{const} \cdot (T - T_c)$. The ratio between κ and λ is given by the relation $n_p = \frac{1}{2} \frac{\kappa^2}{\lambda^2}$, where n_p is the average density of pairs in the material. Finally, κ is linked to the value of the Ginzburg-Landau parameter $\kappa = \frac{\lambda}{\xi}$ by the relation $\kappa^2 = \frac{m^2}{2\phi_0^2 e^2}$. Two further important points which should be taken into account are (i) the boundary conditions on $\mathbf{g}_L$ at the superconductor/ normal conductor and superconductor/ionized gas interfaces; (ii) the intrinsic anisotropy of HTC materials, which actually also affects the form of the GL free energy.

The relative importance in eq. (12) of the terms with the gradients and the term proportional to $\mathbf{g}_L^2$ depends on the length scale at which the variations of $\mathbf{g}_L$ can occur. If, as usual for Type II and HTC superconductors, this scale is of the order of 10^{-8} m or less, the terms with the gradient dominate.

It is straightforward to check that the sign of L is negative, except for two types of configurations:

(1) For the constant solutions of the Ginzburg-Landau equation in the absence of external field, namely $\langle \mathbf{x} \rangle = n_p$. The corresponding constant Lagrangian density is $L_1 = \frac{1}{2} n_p^2$.

(2) For regions of the condensate where $\mathbf{r}^2$ is negative and greater, in absolute value, than $(\mathbf{r} \cdot \mathbf{r})^2$. It is straightforward to check that these are regions located around local density maximums, or more generally about lines and surfaces where the first partial derivatives of $\mathbf{g}_L$ are zero and the second derivatives are negative or null. The Lagrangian density at a maximum is $L_2 = \frac{1}{2} \mathbf{m} \cdot \mathbf{j} \cdot \mathbf{j}$. If the maximum is sharp, L can be much larger than for constant solutions. Configurations of this kind are characteristic of solutions of the Ginzburg-Landau equation with strong magnetic flux penetration [27].

Now we make some numerical estimates of L . Assuming for YBCO 10^{27} m^{-3} , 10^{-9} m, 10^2 , we obtain for the configurations (1) and (2) densities $L_1 = 10^4 \text{ J/m}^3$ and $L_2 = 10^7 \text{ J/m}^3$, respectively. With reference to our experiment we must explain, on the basis of these figures, why anomalous coupling at the emitter takes place, but only at the moment of the discharge and in presence of strong magnetic flux penetration.

We remind that the vacuum energy density acts as cut-off for the dipolar fluctuations, so that their maximum amplitude A is inversely proportional to ω . Therefore in presence of a local contribution by the superconductor we have

$$\frac{1}{A} \Big|_{j=8 \text{ G}} \propto L_j \quad (13)$$

So an amplification of the fluctuations is possible when L has the same sign as ω . From the experimental observations it is clear that a negative value of L does not give the necessary conditions. In fact, in that case anomalous coupling would be observed every time there are strong density gradients in the superconducting material - which occurs almost always. From this we obtain a first piece of information about the value of ω at atomic scale (otherwise unknown): it must be positive. $j=8 \text{ G}$ must furthermore be much larger than L_1 , because a constant density does not give observable anomalous effects

either. In conclusion, $\approx 8 \text{ G}$ must be larger than L_2 , and the amplitude A of the dipolar fluctuations increases as the local value of L approaches it from below.²

This can happen in presence of strong magnetic flux penetration (Point 2 above), but that requisite is not sufficient: the presence of a strong transport current is also necessary. In fact, with strong flux penetration, the density is depressed. The current appears like a means to obtain at once a large and a large value of ρ_0 in correspondence of the maximums. Indeed, in inhomogeneous materials like HTC's, a very intense transport current inevitably forces a large density in certain regions. In the case of the weak gravitational shielding [1] the transport current is mostly due to the accelerated rotation of the disk [28]. In the present case it is due to the discharge.

(g) The anomalous coupling inside the condensate modifies the field also outside.

Summarizing, we can say that in particular conditions a quantum condensate is able to modify locally the cosmological term of the gravitational action. In turn, the cosmological term fixes the cut level of the dipolar fluctuations, and so the local gravitational vacuum polarizability. Therefore an anomalous coupling of the condensate with the gravitational field is observed. This coupling can be abnormally strong, due to the large amplitude of the vacuum fluctuations. It is a kind of coupling that completely eludes the standard form and so is not proportional, through the $G=c^4$ constant, to the energy-impulse content of the condensate.

The next question is: how is the gravitational field modified inside the condensate and in its neighbourhood? In other words, let us suppose that the gravitational field displays a much higher level of dipolar fluctuations in some regions of the condensate. What is the consequence for the global behaviour of the field? For instance, with reference to the static experiment, why is there a noticeable reduction of the terrestrial field above the disc? We can say that in that case there is a big gravitational source - the earth - producing a uniform field in the region of interest, according to the usual classical field equations. Into these equations, however, we must also introduce a kind of "random source" located in the condensate. This affects the field also outside.

(h) The modified field equation contains an arbitrary constant.

We have proposed to introduce into the gravitational field equations a term representing a random source located in the condensate. This procedure has some intrinsic arbitrariness. The intensity of the source is arbitrary, too, and cannot be obtained from the ratio between the energy density of the condensate and the "natural" vacuum energy density. In fact, it is true that this ratio allows us to determine the maximum amplitude of the dipolar fluctuations. However, the probability of these fluctuations, and so their weight with respect to the external configurations, is still an unknown element of the theory. We know that certain field configurations give a null contribution to the pure Einstein

²The density L_2 can be compared with that obtainable for an electromagnetic field alone - which can also be regarded as "coherent matter" in this context. The electromagnetic energy density is proportional to $(\mathbf{E}^2 + \mathbf{B}^2)$, but the action density is proportional to $(\mathbf{E}^2 - \mathbf{B}^2)$, therefore only an electrostatic field has the right sign. But even with a field strength of $3 \cdot 10^6 \text{ V/m}$, one obtains a density of 100 J/m^3 , definitely lower.

action and can grow up without limit, and we can determine the cut-off amplitude due to the intervention of the cosmological term; however, the probability that these fluctuations really happen is a feature of the quantum theory, which is not known yet. In principle, it would be possible to write a functional integral containing all the involved fields, the test masses etc., evaluate it and obtain everything. In practice, what we can do with such an integral is only a weak field expansion about the minimum of the action.

In conclusion, if we represent the gravitational fluctuations in the quantum condensate as a random source, the intensity of this source must be inserted as a parameter which is fixed "a posteriori" from the experimental data. This should not be unexpected. The experimental observations described in this work are absolutely new and unprecedented. They inform us about a sector of the theory which is otherwise unknown. The validity of our model consists of suggesting a new interaction process, while avoiding contradictions with known facts, and while giving the freedom to fix a new coupling constant.

(i) The modified field equation must be able to describe the observed phenomenology.

After modelling the effect of the fluctuations on the external field (for instance, as random source with a certain strength), we are able to verify the consistency and correctness of the procedure by calculating this field and comparing the result to the data - not only as intensity but also as shape. For instance, we know that in the static experiment a "shielding cylinder" was observed which extended far above the superconducting disc and showed net borders, without diffraction. Obtaining this characteristic from the field equations modified by the anomalous coupling is all but trivial. The observed field configuration is furthermore clearly not conservative. (This can be understood remembering that there is a source term in the equation.) Nonetheless, we succeeded in [20] in obtaining a result of this kind (see also [29]).

(j) Euclidean and Lorentzian formulation of the anomalous coupling and of the modified action.

From the technical point of view, the general program outlined above has been implemented in the Euclidean (or imaginary-time) version of quantum gravity [18, 19, 20], and more recently in the standard Lorentzian version [21].

The occurrence of the dipolar fluctuations and the cut-off role of the vacuum energy density are most clearly and safely exhibited in the Lorentzian formalism. On the other hand, the Euclidean formulation is reliable and more suitable for perturbative calculations of the modified field equations.

The Lorentzian formulation is indispensable for the latest developments (calculation of the low-energy limit of L and determination of its sign as a function of ϕ).

4.2 Possible interpretation of the gravitational-like impulse at the discharge

We focus now our attention on the new, puzzling effects described in the experimental part of this paper, and partially analysed at the beginning of this Section. We cannot offer any

quantitative interpretation of these effects yet, so we shall limit ourselves to an hypothesis based on our previous work on the static effect.

(a) From the static to the transient effect: the virtual dipoles emit virtual radiation.

We have seen that the observed impulse can neither be described as a real radiation, nor as a quasi-static field. These are the two types of field configurations which are predicted by any classical theory.

However, we also saw that the weak gravitational shielding effect can be explained introducing the concept of anomalous dipolar quantum fluctuations induced by the condensate. These fluctuations locally increase to observable levels the gravitational vacuum polarizability.

In the transient case, the virtual dipolar fields are rapidly varying in time, because the critical conditions in the quantum condensate are produced only for a short time at the discharge. Therefore it is natural to expect that in this case the formation of virtual dipoles is accompanied by the emission of virtual dipolar radiation.

(b) In quantum mechanics every interaction is equivalent to an exchange of virtual radiation.

Let us recall the concept of "virtual radiation" as intermediate state of a quantum process. In quantum mechanics, every interaction is thought to take place through the exchange of virtual particles - photons, gauge bosons, gravitons. This is especially clear in scattering processes, but also the static interaction potential can be written as an integral over time and four-momentum of the propagator of a mediating virtual particle [30]. In this integral, all values of energy-momentum are included, not only the "on-shell" values satisfying the condition $E = pc$ which is typical of real photons and gravitons. This is possible just because the mediating particles are virtual, i.e. so short-living that the Heisenberg principle allows for a large indetermination in their energy. In fact, the static force obtained as a sum of virtual processes is very different from the effect of a collection of free photons or gravitons.

It is also possible to compute along these lines the quantum corrections to the classical force. To this end, one includes in the sum some less probable processes, involving the exchange of several mediating particles at the same time, or the creation-annihilation of virtual pairs, and so on.

(c) The impulse at the discharge is made of on-shell gravitons.

In order to explain the weak gravitational shielding effect we hypothesised an anomalous strong quantum correction to the field of the earth. In the transient case, on the other hand, all the emitted "radiation" should be regarded as a quantum effect. The observed impulsive force could be the effect of virtual processes in which:

1. The intense supercurrent flowing across the superconducting cathode produces critical gravitational regions, with strong dipolar vacuum fluctuations. The necessary conditions are those discussed in Section (4.1-f).

2. These fluctuations emit a beam of virtual on-shell gravitons with $E = pc$. The direction of the beam is sharply defined by momentum conservation. Whatever the exact microscopic mechanism, the momentum carried by the virtual radiation can only originate from that of the Cooper pairs entering the critical regions, i.e. from the momentum of the supercurrent. This is in agreement with the fact that if the impact direction of the discharge changes (like in the earlier set-up, see 3), also the direction of the emitted radiation changes.

3. When the beam hits a mobile target, it conveys an impulse to this target. Like for usual gravitational forces (which can also be interpreted as graviton exchange, as mentioned), interposed bodies do not affect transmission.

4.3 Known effects which could be connected to the observed phenomenon.

The following concepts are often quoted to explain anomalous gravitational effects. So we summarise them quickly, even though in our case they do not fit to the observed phenomenology.

We recall that several alternative theories were proposed, in the last decades, in the attempt to "explain" and give a physical basis to spacetime and vacuum. Every one of these, to be credible, must first of all reproduce the known results of general relativity and quantum field theory. Notable examples are theories of "induced" gravity according to Sakharov's idea [31], and string theory. It is not easy to judge if anyone of these theories can also predict, in addition, unusual effects in the presence of superconductors. Some are not developed enough to give a definite answer. Many have been proposed recently, still their authors did not envisage any anomalous coupling to matter in a macroscopic quantum state. In general, if the coupling of gravity to matter conforms to the classical Einstein equations, then the intensity of any generated gravitational field will depend only on the energy-momentum of the source multiplied by $G=c^4$, so there is no chance for anomalous effects. A notable exception could be torsion theory, which predicts a coupling to quantum spin not allowed in the Einstein equations; however, as we shall see below, there are strict experimental limits on the coupling of matter to torsion. Another possibility is to consider strong quantum effects, as done in Section 4.2; in that case, we chose to start from the standard form of the classical theory.

(a) The gravitomagnetic field

Could the observed anomalous forces be due to the fact that the superconductor produces during the discharge a strong gravitomagnetic field? It is well known from general relativity that the gravitational field contains components of magnetic type, called the gravitomagnetic field. These components have the property to be produced by moving objects and to act on objects in movement. It is possible to write the Einstein field equations in weak field approximation in a form very similar to that of Maxwell equations. The important difference, with respect to the Maxwell equations for electromagnetism, is that gravitomagnetic effects are suppressed by factors $1/c$ or $1/c^2$. So they are always very small with respect to "gravitoelectric" effects - those which have a Newtonian limit. See for instance [32, 33]; in these references an analysis of the Maxwell equations for

gravity and also of the "Gravity Probe B gyroscope experiment" for detecting the Earth's gravitomagnetic field is given.

In certain conditions the gravitomagnetic field can be repulsive. In neutron stars it can produce a gravitational analogue of the Meissner effect. As one would expect, however, the "gravitational Meissner effect" is exceedingly weak: for instance, it has been computed that in a neutron star with a density of the order of 10^{14} g/cm^3 , the London penetration depth is ca. 12 km [34]. In the 1970s experiments were done to detect possible weight decreases of a rotor while it was rotating at very high speed [35], but conclusive results were never obtained.

(b) Gravitomagnetism and quantum spin

The aspects of the theory of quantum gravity concerning the spin are summarized, for instance, in [36]. In previous work [37] O'Connell examined the implications arising from the fact that spin contributions to the gravitational potential are as large as the spin-independent contributions for interparticle separations of the order of Compton length and also that such spin-dependent forces could be repulsive for certain spin orientations. An analysis was also carried out of the possibility of measuring gravitational spin-dependent forces in the laboratory [38]. An idea of one such experiment, as proposed in [39], is to observe a breaking of the equilibrium of a polarized body, hanging in the gravitational field, when its polarized state is destroyed. This effect, if present, is predicted to be extremely small. (See also the results by Ritter et al. [40].) Claims like those by Wallace of "antigravity" forces produced by spin orientation in nuclei [41] appear as totally unreliable today.

(c) The works by Ning Li and Torr

In a series of articles Ning Li and Torr [6] calculated the gravitomagnetic field which would be produced by a superconductor containing circulating supercurrents. According to them, in this case also the movement of the ions, which produce a current of mass, has particular importance. Also the fact that spin alignment is present would be very important. The alignment of the spin of the lattice ions would be a source of gravitomagnetic field. The objections to this model are of two types. First, the total spin amount that is possible to obtain in normal condensed matter is always very small, also in presence of alignment. Therefore, given the weak coupling with the gravitomagnetic field, one does not understand how it could reach detectable intensity. Another objection is of more technical nature. Ning Li and Torr use the Maxwell equations for gravity, which hold in weak field approximation. However, when they find that some terms of these equations "explode", they keep this result even if it is inconsistent with the initial approximation.

Previously to the first Podkletnov experiment [1] and without reference to it, Ning Li and Torr determined another consequence of their model [7]. Not only the alignment of the spin of the lattice ions would produce a gravitomagnetic field, but in the presence of an outside applied time-dependent vector potential, this would be converted into a perceptible gravitoelectric field. Such a conversion is necessary, if one wants to apply this theory to the weak gravitational shielding, because in that case the test bodies are at rest, and so they would not respond to a gravitomagnetic field. However, this is in contrast with the

short-lived permanence of the effect also after all the outside fields are turned off. At last, we notice that Ning Li and Torr never published a work in which they try to interpret the phenomenology of the effect in terms of their model nor to explain why it is observed only with certain types of superconductors.

(d) Other models connected to gravitomagnetism

There have been proposals of alternative interpretations of gravitomagnetism in connection with the Mach principle [45]. In this context, the gravitomagnetic phenomena would achieve a greater importance. Still with reference to a Machian theory, Woodard claims to have experimentally obtained some transient fluctuations in the inertial mass of a capacitor [46]. However we will not be concerned here with these approaches, which to a large extent remained at a subjective level.

Recently Ummarino [42] tried to establish a link between the Podkletnov effect and the gravitomagnetic and gravitoelectric field, following a more standard approach, connected with the Ginzburg-Landau theory for superconductors.

(e) Theories with torsion

We now come to the theories of gravity with torsion. Could the observed phenomenology, not understandable in general relativity, be related to the existence of a torsion field? Let us first recall how the concept of torsion was born: from the idea of considering the connection (which in the metric formalism is simply a quantity derived from the metric and is symmetric with respect to a couple of indexes) like an independent quantity, with its own dynamics and, generally, not symmetric. Torsion theory is an extension of general relativity, which was investigated in great detail in the past. It is necessary in fact in order to introduce the interaction of the gravitational field with the quantum spin, and allows to connect general relativity to the usual gauge theories. After admitting the possibility of the existence of torsion, its features (for instance, its propagation), do not descend from first principles or from the geometrical structure of the theory, but from the form of the various possible terms in the action and from coupling constants fixed on the basis of experimental observations. Over the years a large amount of experimental data have been accumulated, which place strong limits on the couplings.

A picture of the current situation is for instance presented by Carroll and Field [43]. What is concluded is that the possible existence of the torsion can be of interest at the level of gravitational interactions at very short distances (Planck scale), but not at the level of laboratory experiments.

In their work Carroll and Field discuss possible actions for torsion and its interaction with matter fields like those of the standard model of particle physics. They construct a free Lagrangian from powers and derivatives of the torsion, and couple it "minimally" to matter through the covariant derivative. They find that there is only a small range of models possible without placing arbitrary restrictions on the dynamics. In these models only a single mode interacts with matter, either a massive scalar or a massive spin-1 field, and each mode is parameterised by two constants with the dimension of mass. They concentrate on the scalar theory, which is related to several proposals found in the literature and discuss what regions of parameter space are excluded by laboratory and astrophysical

data. Carroll and Field find that a reasonable expectation would be for each of the two mass parameters to be of the order of the Planck scale; such a choice is a safe distance away from the regions excluded by experiment. They conclude that, while there are reasons to expect that the torsion degrees of freedom exist as propagating fields, there is no reason to expect any observable signature from torsion.

Other "not orthodox" points of view are represented in literature [44]. But even though theories of torsion exist since a long time, no attempts to explain the phenomenology of the Podkletnov effect were ever presented.

(f) The value of G and the measurements at short distances

The fundamental characteristics of the gravitational interaction keep on being a very alive and interesting research field. We do not mean by this the consequences of gravity on the structure of the universe, and so the applications of general relativity to black holes, astrophysics etc.; we mean the basic features of the force, including the issue whether general relativity is an adequate and complete description of it. We recall that only two predictions of general relativity have not been verified yet, namely the existence of gravitational waves and of gravitomagnetic fields. There are furthermore several current experiments to detect possible violations of the equivalence principle. Up to now no contradiction has ever been observed with respect to the predictions of general relativity [47].

The precision with which the value of G is known is clearly unsatisfactory compared to the precision with which the other fundamental physical constants are known. This is also due to the fact that while the definition of the other fundamental constants relies on microscopic experiments performed with high precision devices, for the G constant it is necessary to use more or less sophisticated versions of the Cavendish experiment. In particular, we do not know the behaviour of gravity at short distances (millimeters or less). According to Gillies [48], in the second half of 1900 more measurements of G were made than ever before. Some discrepancies were observed in recent times with respect to the best official value fixed in 1982.

The value of G has been called into question by new measurements from respected research teams in Germany, New Zealand, and Russia [49]. The new values disagree wildly. For example, a team from the German Institute of Standards obtained a value for G that is 0.6% larger than the accepted value; a group from the University of Wuppertal in Germany found a value that is 0.06% lower and one at the Measurement Standards Laboratory of New Zealand measured a value that is 0.1% lower. The Russian group found a space and time variation of G of up to 0.7%. The collection of these new results suggests that the uncertainty in G could be much larger than originally thought. This controversy has spurred several efforts to make a more reliable measurement of G .

A recent theoretical prediction suggests that gravity penetrates extra, compact dimensions so that the gravitational inverse square law must be modified at short ranges (less than 1 mm). Arkani-Hamed, Dimopoulos, and Dvali [50], have offered this as an explanation of the hierarchy problem. A team at the university of Washington is doing new measurements in order to check this, but results are negative up to now [51].

(g) The anomalous acceleration of the Pioneer and scalar-tensor theories

Let us now pass from the shortest distances at which it is possible to observe gravitational interactions in the laboratory, to the largest. Surprising results were obtained recently by the observation of the motion of the Pioneer space probes [53]. Direct measurements are possible thanks to the radio signals transmitted by the spacecrafts, which give precise information about their position, speed and acceleration. From the analysis of the data a residual acceleration was found, not explainable through the usual orbit tracking models. Some proposals for a theoretical explanation of the phenomenon were presented. One of these [54] calls for the existence, in addition to Einstein's gravitational field, of a scalar field which, supposed it has certain properties, could lead to the observed effect. This field could also be responsible for the rotation anomalies observed in the galaxies, because it gives a modification of the behaviour of gravity at large distances. The cited model belongs in practice to a wide group of extensions of the standard theory of gravitation [52], which originate from the Brans-Dicke model and in more recent times refer to string theory and to the so-called dilaton field.

(h) Gravitational anomalies at solar eclipses

There is a long history of claims of possible anomalous changes of gravity during sun eclipses. These would be different from tidal changes, which are well known and calculable with precision, and could show that some kind of shielding of the solar attraction by the moon exists, at the moment when it steps in between the earth and the sun. The data, however, are quite contradictory [55].

The original experiments by Allais, in which the change of the oscillation period of a pendulum was observed, seemed to imply a decrease in g of about 1/100 of the solar gravity. The consequence would be an apparent increase of the terrestrial attraction of about one part in a million. During the eclipse of 2000 a net of observers with pendulums and gravimeters was organised by initiative of the NASA, in order to observe possible changes; the definitive results are not available yet. A work was published in 2000 by a Chinese team, with reference to the eclipse of 1997 [56], in which data measured with a high precision gravimeter are reported. Also in this case, some anomalies were observed at the eclipse, but with features very different from those reported before. There is a noticeable decrease of the terrestrial attraction, that is, an apparent anti-screening of the solar gravity. The shielding factor is much smaller than the one declared by Allais, and the time sequence rather strange, with maxima at the beginning and the end of the darkness period.

It is important to remember that other experiments clearly exclude any shielding of gravitation of the so-called "Majorana" type (these phenomena were first investigated by Majorana at the beginning of 1900) [57]. Besides, one would expect a possible shielding effect by the moon to have an analogue for artificial satellites, namely a shielding of solar gravity when the satellite enters the shadow of the earth. Anomalies of this type were actually reported [58], though they are very difficult to confirm, because the irregularities which affect the motion of the artificial satellites are numerous, especially when they are close to the surface of the earth.

(i) Weak gravitational shielding by superconductors

In this variegated field of investigations on possible gravitational anomalies, the work by E. Podkletnov stands out, originally appeared in 1992 [1], then in improved version in 1995 [2]. It describes possible gravitational anomalies caused by HTC superconductors. The observed anomalies reached a maximum of about 2% of g , in transient situations, and 0.3-0.5% of g in almost stationary form. These anomalies were produced by means of discs with multiple layers, rotating at high speed, in very particular conditions, which still have not been completely duplicated. A NASA team already produced a first simplified reproduction of the experiment in 1997 [3], and a new version should start giving some data this year. Besides the remarkable experimental difficulties, the results are puzzling under the theoretical point of view. In fact, the strength of the anomalies is very large with respect to what has been previously observed, and no sufficiently complete theory exists, which can explain this kind of phenomena (see Section 4.1). Here in fact both gravitation is called into play, of which a complete quantum theory does not exist, and typically quantum phenomena (behaviour of the macroscopic wave functions in superconductors). Furthermore, not conventional superconductors are involved, but HTC superconductors, for which several issues are still unsettled, like the pairing mechanism etc.

(j) Terahertz radiation emission by HTC superconductors

A new type of terahertz radiation was discovered by Japanese scientists by irradiating HTC superconductive films with femtosecond laser pulses [59, 60]. The radiation mechanism is thought to be connected with the ultrafast supercurrent modulation by the laser pulses, which induces nonequilibrium superconductivity. The principal design of the experimental installation has some common features with our gravity impulse generator and the behavior of the superconducting crystallized materials might have a similar origin.

5 Conclusions

The experimental apparatus has shown that an impulse of gravitational-like force freely propagating through different physical media can be generated by a dual layered YBCO HTSC under pulsed electric current. The impulse propagates parallel to the direction of the discharge and orthogonal to the surface of the HTSC. The intensity of the impulse has been found to increase with increasing discharge energy, and to depend on the chemical composition and structure of the HTSC and on its internal magnetic state. In a typical measurement, the mechanical energy imparted by the impulse to a pendulum of mass 18.5 g was between $4 \cdot 10^{-4}$ J and $23 \cdot 10^{-4}$ J (Table 1).

From the theoretical point of view, we understand the effect as the result of an anomalous interaction between a special class of gravitational vacuum fluctuations and the macroscopic wave function of the superconductor. This interaction is locally activated when the product of the pairs density and its second derivative ρ'' is sufficiently large. The sign of ρ'' must furthermore be positive. These conditions can be satisfied in the presence of intense transport current and magnetic flux penetration.

Attempts of scientists to control gravity have been present for a long time and in the future these efforts will almost certainly become more prominent. Albert Einstein spent the

last years of his life trying to integrate gravity with the other laws of physics and the entire scientific community remains intrigued with the problem of gravity ever since. However, since our knowledge of gravity is poor in comparison to that of the other fundamental forces, we are unable to control it in any fundamental way. We are therefore left with the option of carrying out experiments based on new theories, on scientific intuition and careful analysis of previous results. This work indicates that a kind of artificial gravity can be generated using the unique properties of superconducting ceramic materials and a combination of electric and magnetic forces.

Acknowledgment - G.M. was supported in part by the California Institute for Physics and Astrophysics via grant CIPA-MG7099.

References

- [1] E. Podkletnov and R. Nieminen, A Possibility of Gravitational Force Shielding by Bulk $\text{Y Ba}_2\text{Cu}_3\text{O}_7$ x Superconductor, *Physica C* Vol. 203 p. 441 (1992).
- [2] E. Podkletnov, Weak Gravitational Shielding Properties of Composite Bulk $\text{Y Ba}_2\text{Cu}_3\text{O}_7$ x Superconductor Below 70 K Under EM Field, LANL Physics Preprint Server, preprint cond-mat/9701074, January 1997. Available on the net: <http://www.gravity.org/msu.html>.
- [3] N. Li, D. Noever, T. Robertson, R. Koczor and W. Brantley, Static Test for a Gravitational Force Coupled to Type II YBCO Superconductors, *Physica C* 281, 260-267. R. Koczor and D. Noever, Fabrication of Large Bulk Ceramic Superconductor Disks for Gravity Modification Experiments and Performance of YBCO Disks Under e.m. Field Excitation, NASA Marshall, Huntsville, AL, AIAA 99-2147, 35th AIAA/ASME/SAE/ASEE Joint Propulsion Conference, 20-24 June 1999, Los Angeles, CA.
- [4] Frederic N. Rounds, Anomalous Weight Behavior in $\text{Y Ba}_2\text{Cu}_3\text{O}_7$ x Compounds at Low Temperature, NASA Ames Research Center. Preprint physics/9705043.
- [5] Harald Reiss, A Possible Interaction Between Gravity and High Temperature Superconductivity-By a Materials Property, Submitted to the 15th. European Conf. Thermophys. Properties, Würzburg, Germany, Sept. 5-9, 1999.
- [6] Ning Li and D. Torr, Effects of a gravitomagnetic field on pure superconductors, *Phys. Rev. D* 43 (1991) 457; Gravitational effects on the magnetic attenuation of superconductors, *Phys. Rev. B* 64 (1992) 5489.
- [7] Ning Li and D. Torr, Gravitoelectric-electric coupling via superconductivity, *Found. Phys. Lett.* 6 (1993) 371.
- [8] G. Fontana, A possibility of emission of high frequency gravitational radiation from junctions between d-wave and s-wave superconductors, report cond-mat/9812070;

Gravitational radiation and its application to space travel, in CP504, Space Technology and Applications International Forum-2000, edited by M.S. El-Genk, AiP, p. 1085.

- [9] M. Agop, C. Gh. Buzea and P. Nica, Gravitational shielding in an electromagnetic eld. Local gravitoelectromagnetic effects on a superconductor, *Physica C: Superconductivity*, 339 (2) (2000) pp. 120-128
- [10] U. Balachandran, R.B. Poeppel, J.E. Emerson, S.A. Johnson, M.T. Lanagan, C.A. Youngdahl, Donglu Shi, K.C. Goretta, N.G. Eror, Synthesis of Phase-Pure Orthorhombic $\text{Y Ba}_2\text{Cu}_3\text{O}_{7-x}$ under Low Oxygen Pressure, *Materials Letters* 8 (1989) 454-456.
- [11] T.B. Lindemer, F.A. Washburn, C.S. MacDougall, O.B. Cavin, Synthesis of Y-Ba-Cu-O superconductors in subatmospheric oxygen, *Physica C* 174 (1991) 135-143.
- [12] M. Murakami, Processing of bulk YBaCuO, *Supercond. Sci. Technol.* vol. 5, pp 185-203, 1992.
- [13] S. Nariki, N. Sakai and M. Murakami, Fabrication of large melt-textured Gd-Ba-Cu-O superconductor with Ag addition, *Physica C: Superconductivity*, 341-348 (1-4) (2000) pp. 2409-2412.
- [14] M. Muralidhar, S. Koishikawa, M.R. Koblishka and M. Murakami, Study of superconducting properties of OCMG processed (Nd, Eu, Gd)-Ba-Cu-O with Pr doping, *Physica C: Superconductivity*, 314 (3-4) (1999) pp. 277-284.
- [15] S.I. Yoo, N. Sakai, T. Higuchi and M. Murakami, Melt processing for obtaining $\text{NdBa}_2\text{Cu}_3\text{O}_y$ superconductors with high T_c and large J_c , *Appl. Phys. Lett.* 65 (1994) pp. 633-635.
- [16] V.R. Todt, X.F. Zhang and D.J. Miller, Nucleation and growth of single- and multiple-domain $\text{Y Ba}_2\text{Cu}_3\text{O}_{7-x}$ Levitators: Influence of Seed Crystallography, *IEEE Trans. on Appl. Super.*, vol. 7(2), pp. 1801-1804, June 1997.
- [17] Chan-Joong Kim, Young A. Jee, Gye-Won Hong, Tae-Hyun Sung, Young-Hee Han, Sang-Chul Han, Sang-Joon Kim, W. Bieger, G. Fuchs, Effects of the seed dimension on the top surface growth mode and the magnetic properties of top-seeded melt growth processed YBCO superconductors, *Physica C* 331 (2000) pp. 274-284.
- [18] G. Modanese, Theoretical analysis of a reported weak gravitational shielding effect, *Europhys. Lett.* 35 (1996) 413-418.
- [19] G. Modanese, Role of a "local" cosmological constant in euclidean quantum gravity, *Phys. Rev. D* 54 (1996) 5002.
- [20] G. Modanese, Tunneling of a massless scalar eld through a 3D gaussian barrier, *J. Math. Phys.* 40 (1999) 3300.

- [21] G. Modanese, Virtual dipoles and large fluctuations in quantum gravity, Phys. Lett. B 460 (1999) 276; Large "dipolar" fluctuations in quantum gravity, Nucl. Phys. B 588 (2000) 419-435; Paradox of virtual dipoles in the Einstein action, Phys. Rev. D 62 (2000) 087502;
- [22] G. Modanese, The dipolar zero-modes of Einstein action: An informal summary with some new issues, in Proceedings of the Vigier III Symp. (Aug. 21-25, 2000, U. California Berkeley), Kluwer Acad. Press.
- [23] A.G. Riess et al., Astronom. J. 116 (1998) 1009; S. Perlmutter et al., Astrophys. J. 517 (1999) 565.
- [24] I.L. Shapiro and J. Sola, On the scaling behavior of the cosmological constant and the possible existence of new forces and new light degrees of freedom, Phys. Lett. B 475 (2000) 236; Scaling behavior of the cosmological constant: interface between quantum field theory and cosmology, report UAB-FT-490, hep-th/0012227.
- [25] G. Modanese, Local contribution of a quantum condensate to the vacuum energy density, report gr-qc/0107073.
- [26] J. Waldram, "Superconductivity of metals and cuprates", IoP, London, 1996.
- [27] D.R. Tilley and J. Tilley, "Superfluidity and superconductivity", IoP, Bristol, 1990.
- [28] G. Modanese, The London field in bulk layered superconductors, report cond-mat/9909441.
- [29] G. Modanese, Gravitational anomalies by HTC superconductors: a 1999 theoretical status report, report physics/9901011.
- [30] For the gravitational case: G. Modanese, Potential energy in quantum gravity, Nucl. Phys. B 434 (1995) 697. For the other cases: K. Symanzik, Comm. Math. Phys. 16 (1970) 48.
- [31] For a recent account and references see C. Barcelo, S. Liberati and M. Visser, Analog gravity from field theory normal modes?, report gr-qc/0104001.
- [32] B. Mashhoon, H. Young Paik and C. Will, Detection of the gravitomagnetic field using an orbiting superconducting gradiometer; theoretical principles, Phys. Rev. D 39, 2825 (1989).
- [33] I. Ciufolini and J. Wheeler, "Gravitation and Inertia", Princeton Series in Physics, Princeton university press, 1995, Chap. 6.
- [34] R.P. Lano, Gravitational Meissner effect, report U.oflowa 96-4, March 1996.
- [35] H. Hayasaka and S. Takeuchi, Phys. Rev. Lett. 63 (1989) 2701.
- [36] B. M. Barker and R. F. O'Connell, The gravitational interaction: spin, rotation and quantum effects - A review, Gen. Rel. Grav. 11 (1979) 149.

- [37] R. F. O'Connell, Phys. Lett. A 32 (1970) 402.
- [38] R. F. O'Connell and S. N. Rasband, Nature Phys. Sci. 232 (1971) 193.
- [39] A. Peres, Phys. Rev. D 18 (1978) 2739. See also Y. N. Obukhov, Spin, gravity, and inertia, report gr-qc/0012102.
- [40] R. C. Ritter, L. I. Winkler, and G. T. Gillies, Search for anomalous spin-dependent forces with a polarized-mass torsion pendulum, Phys. Rev. Lett. 70 (1993) 701.
- [41] H. Wallace, Method and apparatus for generating a secondary gravitational force eld, US Patent N. 3626605 (1971).
- [42] G. A. Ummarino, Possible alterations of the gravitational eld in a superconductor, report cond-mat/0010399.
- [43] S. M. Carroll and G. B. Field, Consequences of propagating torsion in connection-dynamic theories of gravity, Phys. Rev. D 50 (1994) 3867.
- [44] A. Ye. Akimov and V. Ya. Tarasenko, Models of polarization states of the physical vacuum and torsion elds, Izd. Vuzov. Fizika, 1992, Nov. 3, pp. 13-23. See also on the Web: <http://www.amasci.com/freenrg/tors/doc17.html>.
- [45] K. Nordtvedt, Int. J. Theor. Phys. 27 (1988) 1395.
- [46] J. F. Woodward, Laboratory test of Mach's principle and strong- eld relativistic grav-ity, Found. Phys. Lett. 9 (1996) 247, and references.
- [47] D.E. Groom et al. (Particle Data Group), Review of particle physics, Eur. Phys. J. **C 15** (2000); <http://pdg.lbl.gov>.
- [48] G. T. Gillies, The Newtonian gravitational constant: recent measurements and related studies, Rep. Prog. Phys. 60 (1997) 151-225.
- [49] W. Michaelis, H. Haars, and R. Augustin, Metrologia 32, 267 (1995). M. Fitzgerald and T. R. Armstrong, IEEE Trans. on Inst. and Meas. 44, 494 (1995). H. Walesch, H. Meyer, H. Piehl, and J. Schurr, IEEE Trans. on Inst. and Meas. 44, 491 (1995). V.P. Izmailov, O.V. Karagioz, V.A. Kuznetsov, V.N. Mel'nikov, and A.E. Roslyakov, Measurement Techniques 36, 1065 (1993).
- [50] N. Arkani-Hamed, S. Dimopoulos, G. Dvali, The Hierarchy Problem and New Dimen-sions at a Millimeter, Phys.Lett. B429 (1998) 263-272.
- [51] C.D. Hoyle, U. Schmidt, B.R. Heckel, E.G. Adelberger, J.H. Gundlach, D.J. Kapner, and H.E. Swanson, Submillimeter Tests of the Gravitational Inverse-Square Law: A Search for "Large" Extra Dimensions, Phys. Rev. Lett. (to be published).
- [52] D. La and P. J. Steinhardt, Phys. Rev. Lett. 62 (1989) 376 for status and references on scalar-tensor gravitational theories. See also S. Calchi Novati, S. Capozziello and G. Lambiase, Newtonian limit of induced gravity, report astro-ph/0005104.

- [53] J.D. Anderson et al., Phys. Rev. Lett. 81 (1998) 2858; Study of the anomalous acceleration of Pioneer 10 and 11, report gr-qc/0104064.
- [54] J.P. Mbelek and M. Lachieze-Rey, report gr-qc/9910105.
- [55] T. Kuusela, New measurements with a torsion pendulum during the solar eclipse, General Relativity and Gravitation, 4, 543-550, 1992. D. C. Mishra, M. B. S. Vyaghreswara Rao, Temporal variation in gravity field during solar eclipse on 24 October 1995, Current Science, 72(11), 782-783, 1997. L. A. Savrov, Experiment with paraconic pendulums during the November 3, 1994 solar eclipse in Brazil, Measurement Techniques, 40 (6), 511-516, 1997. And references.
- [56] Qian-shen Wang et al., Precise measurement of gravity variations during a total solar eclipse, Phys. Rev. D 62 (2000) 041101. C.S. Unnikrishnan, A. K. Mohapatra, G.T. Gillies, Anomalous gravity data during the 1997 total solar eclipse do not support the hypothesis of gravitational shielding, Phys. Rev. D 63 (2001) 062002.
- [57] New limits on the gravitational Majorana screening from the Zurich G experiment, C.S. Unnikrishnan, G.T. Gillies, Phys. Rev. D 61 (2000) 101101
- [58] T. Van Flandern, Possible new properties of gravity, Astrophys. Space Sci. 244 (1996) 249, and ref.s.
- [59] M. Tonouchi, M. Tani, Z. Wang, K. Sakai, N. Wada, M. Hangyo, Novel Terahertz Radiation from Flux-Trapped Y Ba₂Cu₃O₇ thin Films Excited by Femtosecond Laser Pulses, Jpn. J. Appl. Phys. Vol. 36 (1997) pp. L93-L95.
- [60] M. Hangyo, S. Tomozawa, Y. Murakami, M. Tonouchi, M. Tani, Z. Wang, K. Sakai, S. Nakashima, Terahertz radiation from superconducting Y Ba₂Cu₃O₇ thin films excited by femtosecond optical pulses, Appl. Phys. Lett. 69 (14), (1996), pp. 2122-2124

Figure Captions

Fig.1 Initial setup of the impulse gravity generator.

Fig.2 Improved variant of the impulse gravity generator.

Fig.3 Discharge chamber of the impulse gravity generator.

Fig.4 Arkadjev-Marx high-voltage pulse generator.

Fig.5 Pendulum in a glass cylinder under vacuum. (The actual cylinder is wide enough to allow a complete oscillation.)

Fig.6 Correlation between the voltage discharge and the deflection of the pendulum.

Fig.7 Impulse recorded by the microphone at a 67 deg. impact angle. Time scale is sampling periods at $f_s = 44.1$ kHz. There is a 50 Hz noise due to power grid. The signal is unfiltered.

Fig.8. Relative pulse impulse versus impact angle.

This figure "figure1and2.jpg" is available in "jpg" format from:

<http://arXiv.org/ps/physics/0108005>

This figure "figure3.jpg" is available in "jpg" format from:

<http://arXiv.org/ps/physics/0108005>

This figure "figure4.jpg" is available in "jpg" format from:

<http://arXiv.org/ps/physics/0108005>

This figure "figure5.jpg" is available in "jpg" format from:

<http://arXiv.org/ps/physics/0108005>

This figure "figure6.gif" is available in "gif" format from:

<http://arXiv.org/ps/physics/0108005>

This figure "figure7.gif" is available in "gif" format from:

<http://arXiv.org/ps/physics/0108005>

This figure "figure8.gif" is available in "gif" format from:

<http://arXiv.org/ps/physics/0108005>

Impulse Gravity Generator Based on Charged $YBa_2Cu_3O_{7-y}$ Superconductor with Composite Crystal Structure

Evgeny Podkletnov¹, Giovanni Modanese²

¹ *Moscow Chemical Scientific Research Centre*
113452 Moscow - Russia
 E-mail: epodkletnov@hotmail.com

² *California Institute for Physics and Astrophysics*
366 Cambridge Ave., Palo Alto, CA 94306
 and
University of Bolzano – Industrial Engineering
Via Sernesi 1, 39100 Bolzano, Italy
 E-mail: giovanni.modanese@unibz.it

Abstract

The detection of apparent anomalous forces in the vicinity of high- T_c superconductors under non equilibrium conditions has stimulated an experimental research in which the operating parameters of the experiment have been pushed to values higher than those employed in previous attempts. The results confirm the existence of an unexpected physical interaction. An apparatus has been constructed and tested in which the superconductor is subjected to peak currents in excess of 10^4 A, surface potentials in excess of 1 MV, trapped magnetic field up to 1 T, and temperature down to 40 K. In order to produce the required currents a high voltage discharge technique has been employed. Discharges originating from a superconducting ceramic electrode are accompanied by the emission of radiation which propagates in a focused beam without noticeable attenuation through different materials and exerts a short repulsive force on small movable objects along the propagation axis. Within the measurement error (5 to 7 %) the impulse is proportional to the mass of the objects and independent on their composition. It therefore resembles a gravitational impulse. The observed phenomenon appears to be absolutely new and unprecedented in the literature. It cannot be understood in the framework of general relativity. A theory is proposed which combines a quantum gravity approach with anomalous vacuum fluctuations.

Contents

1	Introduction	2
2	Experimental	2
2.1	General description of the installation	2
2.2	Superconducting emitter, fabrication methods	4
2.3	Organization of the discharge and measurements of the effect.	6

3	Results	7
4	Discussion	10
4.1	A possible theoretical explanation. Basic concepts.	12
4.2	Possible interpretation of the gravitational-like impulse at the discharge . .	19
4.3	Known effects which could be connected to the observed phenomenon. . . .	21
5	Conclusions	26

1 Introduction

Experiments showing possible anomalous forces between high- T_c ceramic superconductors under non equilibrium conditions and test objects have been reported by several investigators since 1992 [1, 2, 3, 4, 5]. The observed phenomenology was difficult to explain and has been attributed to a so called “gravity modification”, because the reported effects mimic well the properties of the gravitational interaction, although their nature has never been clearly understood. In fact several alternative explanations of these results have been proposed [6, 7, 8, 9, 42] in the attempt to bring the observed anomalies into the realm of known effects.

Because of the great importance of any possible technical application of the reported effects, research activities have started in many laboratories since the first observation of the phenomenon [1]. Our recent research work focused on the improvement of the structure of the high- T_c ceramic superconductors which have demonstrated capabilities of creating anomalous forces. Moreover a high-voltage discharge apparatus has been designed and constructed in order to easily reach those non equilibrium electromagnetic conditions that seem required to produce the force effects in HTCS.

The results described in this report should be regarded as preliminary. An improved version of the experiment is currently being planned. Nevertheless, the body of results, as well as the complexity of the experimental procedures and of the theoretical interpretation are such that a detailed description and diffusion could not be further delayed. All measurements were done by E. Podkletnov in Moscow, while G. Modanese provided theoretical advice.

2 Experimental

2.1 General description of the installation

The initial variant of the experimental set-up was based on a high-voltage generator placed in a closed cylinder chamber with a controlled gas atmosphere, as shown in Fig. 1. Two metal spheres inside the chamber were supported by hollow ceramic insulators and had electrical connections that allowed to organize a discharge between them, with voltage

up to 500 kV . One of the spheres had a thin superconducting coating of $YBa_2Cu_3O_{7-y}$ obtained by plasma spraying using a “Plasmatech 3000S” installation. This sphere could be charged to high voltage using a high voltage generator similar to that of Van de Graaf. The second sphere could be moved along the axis of the chamber, the distance between the spheres varying from 250 to 2000 mm . Spheres with a diameter from 250 to 500 mm were used in the experiment. It was possible to fill the chamber with helium vapours or to create rough vacuum using a rotary pump. The walls of the chamber were made of non-conducting plastic composite material, with a big quartz glass window along one of the walls which allowed to observe the shape, the trajectory and the colour of the discharge. In order to protect the environment and the computer network from static electricity and powerful electromagnetic pulses, the chamber could be shielded by a Faraday cage with cell dimensions of 2.0×2.0 cm and a rubber-plastic film material absorbing ultra high frequency (UHF) radiation.

The superconducting sphere was kept at a temperature between 40 and 80 K , which was achieved by injecting liquid helium or liquid nitrogen through a quartz tube inside the volume of the superconducting sphere before the charging began. The inside volume of the chamber was evacuated or filled with helium in order to avoid the condensation of moisture and different gases on the superconducting sphere. The temperature of the superconductor was measured using a standard thermocouple for low temperature measurements and was typically around 55-60 K . Given the good heat conductivity of the superconductor, we estimated that the temperature difference in the ceramic did not exceed 1 K .

An improved variant of the discharge chamber is shown in Fig. 2. The charged electrode was changed to a toroid attached to a metal plate and a superconducting emitter which had the shape of a disk with round corners. The non-superconducting part of the emitter was fixed to a metal plate using metal Indium or Wood’s metal, the superconducting part of the emitter faced the opposite electrode. The second electrode was a metal toroid of smaller diameter, connected to a target. The target was a metal disk with the diameter of 100 mm and the height of 15 mm . The target was attached to a metal plate welded to the toroid.

This improved design of the generator was able to create a well-formed discharge between the emitter and the target, still the trajectory was not always repeatable and it was difficult to maintain constant values of current and voltage. The chamber was also not rigid enough to obtain high vacuum and some moisture was condensing on the emitter, damaging the superconducting material and affecting the discharge characteristics. The large distance between the electrodes also caused considerable dissipation of energy during discharge. In order to improve the efficiency of operation, the measuring system and the reproducibility of the discharge, an entirely new design of the vacuum chamber and the charging system was created.

The final variant of the discharge chamber is presented in Fig. 3 (the apparatus is shown in a vertical position though actually it is situated parallel to the floor). This set-up allowed to reduce the dimensions of the installation and to increase the efficiency of the process. The chamber has the form of a cylinder with the approximate diameter of 1 m and the length of 1.5 m and is made of quartz glass. The chamber has two connecting sections with flanges which allow to change the emitter easily. The design permits to

create high vacuum inside or to fill the whole volume with any gas that is required. The distance of the discharge has been decreased considerably giving the possibility to reduce energy dissipation and to organize the discharge in a better way. The distance between the electrodes can vary from 0.15 to 0.40 *m* in order to find the optimum length for each type of the emitter.

The discharge can be concentrated on a smaller target area using a big solenoid with the diameter of 1.05 *m* that is wound around the chamber using copper wire with the diameter of 0.5 *cm*. The magnetic flux density is 0.9 *T*. A small solenoid is also wound around the emitter (Fig. 3) so that the magnetic field can be frozen inside a superconductor when it is cooled down below the critical temperature.

The refrigeration system for the superconducting emitter provides a sufficient amount of liquid nitrogen or liquid helium for the long-term operation and the losses of gas due to evaporation are minimized because of the high vacuum inside the chamber and thus of a better thermal insulation.

A photodiode is placed on the transparent wall of the chamber and is connected to an oscilloscope, in order to provide information on the light parameters of the discharge. Given the low pressure and the high applied voltage, emission of X-rays from the metallic electrode cannot be excluded, but the short duration of the discharge makes their detection difficult. Use of a Geiger counter and of X-rays sensitive photographic plates did not yield any clear signature of X-rays.

A precise measurement of the voltage of the discharge is achieved using a capacitive sensor that is connected to an oscilloscope with a memory option as shown in the upper part of Fig. 3. Electrical current measurements are carried out using a Rogowski belt, which is a single loop of a coaxial cable placed around the target electrode and connected to the oscilloscope.

The old fashioned Van de Graaf generator used in the previous stage of this work was replaced by a high voltage pulse generator as shown in Fig. 4. This pulse generator is executed according to the scheme of Arkadjev-Marx and consists of twenty capacitors (25 *nF* each) connected in parallel and charged to a voltage up to 50-100 *kV* using a high voltage transformer and a diode bridge. The capacitors are separated by resistive elements of about 100 *kΩ*. The scheme allows to charge the capacitors up to the needed voltage and then to change the connection from a parallel to a serial one. The required voltage is achieved by changing the length of the air gap between the contact spheres C and D. A syncro pulse is then sent to the contacts C and D which causes an overall discharge and serial connection of the capacitors and provides a powerful impulse up to 2 *MV* which is sent to the discharge chamber. The use of such an impulse generator allows for a precisely controlled voltage, much shorter charging time and good reproducibility of the process.

2.2 Superconducting emitter, fabrication methods

The superconducting emitter has the shape of a disk with the diameter of 80-120 *mm* and the thickness of 7-15 *mm*. This disk consists of two layers: a superconducting layer with chemical composition $YBa_2Cu_3O_{7-y}$ (containing small amounts of *Ce* and *Ag*) and

a normal conducting layer with chemical composition $Y_{1-x}Re_xBa_2Cu_3O_{7-y}$, where Re represents Ce , Pr , Sm , Pm , Tb or other rare earth elements. The materials of both layers were synthesized using a solid state reaction under low oxygen pressure (stage 1), then the powder was subjected to a melt texture growth (MTG) procedure (stage 2). Dense material after MTG was crushed, ground and put through sieves in order to separate the particles with the required size. A bi-layered disk was prepared by powder compaction in a stainless steel die and sintering using seeded oxygen controlled melt texture growth (OCMTG) (stage 3). For the emitters with the diameter of 120 mm usual sintering was applied instead of seeded OCMTG (stage 4). After mechanical treatment the ceramic emitter was attached to the surface of the cooling tank in the discharge chamber using Indium based alloy.

Stage 1 - Micron-size powders of Y_2O_3 and CuO , $BaCO_3$ were mixed in alcohol for 2 hours, then dried and put in zirconia boats in a tube furnace for heat treatment. The mixture of powders was heated to 830 °C and kept at this temperature for 8 hours at oxygen partial pressure of $2.7 \cdot 10^2$ Pa (or 2-4 mBar) according to [10, 11]. The material of the normal conducting layer was sintered in a similar way.

Stage 2 - Micron-size powder of $YBa_2Cu_3O_x$ was pressed into pellets using a metal die and low pressure. The pellets were heated in air to 1050 °C (100 °C per hour) then cooled to 1010 °C (10 °C per hour) then cooled to 960 °C (2 °C per hour) then cooled to room temperature (100 °C per hour) according to a standard MTG technique [12, 13]. The quantity of 211 phase during heating was considerably reduced and the temperature was changed correspondingly. $ReBa_2Cu_3O_{7-x}$ was also prepared using MTG, but the temperature was slightly changed according to the properties of the corresponding rare earth oxide.

Stage 3 - Bulk material after MTG processing was crushed and ground in a ball mill. The particles with the size less than 30 μm were used for both layers of the ceramic disk. The particles were mixed with polyvinyl alcohol binder. The material of the first layer was put into a die, flattened and then the material of the second layer was placed over it. The disk was formed using a pressure of 50 MPa. The single crystal seeds of $Sm123$ (about 1 mm³) were placed on the surface of the bi-layered disk so that the distance between them was about 15 mm and the disk was subjected to a OCMTG treatment in 1% oxygen atmosphere. The growth kinetics of YBCO superconductor were controlled during isothermal melt texturing. A modified melt texturing process was applied, where instead of slow cooling following melting, isothermal hold was employed in the temperature range where the growth is isotropic. By this modification, the time required to texture the disk was reduced to 7 hours which is about 10 times faster than a typical slow cooling melt texturing process. The crystallization depth was controlled by applying the corresponding temperature and time parameters. Cubic $Sm123$ seeds were obtained using the nucleation and growth procedure as described in [16, 17]. A thin layer of the material was removed from the top surface of the disk to a depth of 0.3 mm and the edges of the upper surface were rounded using diamond tools.

Stage 4 - For the emitters with the diameter of 120 mm it is technically difficult to apply seeded MTG method, therefore normal sintering was carried out. Bulk material after MTG processing (after stage 2) was crushed and sieved and the following size particles

were used for both layers of the ceramic disk, the amount is given in weight percent:

500-400 μm	50-60%
120-60 μm	25-35%
< 20 μm	15-25%

The particles were mixed according to the ratio listed above using polyvinyl alcohol as a binder. The material of the first layer was put into a die, flattened and the material of the second layer was placed over it. The disk was formed using the pressure of 120 MPa and sintered in oxygen at 930 $^{\circ}C$ for 12 hours followed by slow cooling down to room temperature. The edges of the upper surface were rounded using diamond tools.

X-ray diffraction, transition temperature, electrical conductivity and critical current density were measured for both layers of various emitters using standard techniques.

2.3 Organization of the discharge and measurements of the effect.

The discharge chamber is evacuated to 1.0 Pa using first a rotary pump and then a cryogenic pump. When this level of vacuum is reached, liquid nitrogen is pumped into a tank inside the chamber that contacts the superconducting emitter. Simultaneously a current is sent to the solenoid that is wound around the emitter, in order to create a magnetic flux inside the superconducting ceramic disk. When the temperature of the disk falls below the transition temperature (usually 90 K) the solenoid is switched off. The experiment can be carried out at liquid nitrogen temperatures or at liquid helium temperatures. If low temperatures are required, the tank is filled with liquid helium and in that case the temperature of the emitter reaches 40-50 K .

The high voltage pulse generator is switched on and the capacitors are charged to the required voltage. It takes about 120 s to charge the capacitors. A syncro pulse is sent to a pair of small metal spheres marked as C and D in Fig. 5. A discharge with voltage up to 2 MV occurs between the emitter and the target. Half a second before the discharge, a short pulse of direct current is sent for 1 s to the big solenoid that is wound around the chamber, in order to concentrate the discharge and to direct it to the same area on the target electrode. This pulse lasts for only 1 s not to cause the overheating of the big solenoid.

The effects are measured along the projection of the axis line which connects the center of the emitter with the center of the target. Laser pointers were used to define the projection of the axis line and impulse sensitive devices were situated at the distance of 6 m and 150 m from the installation (in another building across the area).

Normal pendulums were used to measure the pulses of gravity radiation coming from the emitter. The pendulums consisted of spheres of different materials hanging on cotton strings inside glass cylinders under vacuum. One end of the string was fixed to the upper cap of the cylinder, the other one was connected to a sphere. The spheres had typically a diameter from 10 to 25 mm and had a small pointer in the bottom part. A ruler was placed in the bottom part of the cylinder, 2 mm lower than the pointer. The deflection

was observed visually using a ruler inside the cylinder (Fig. 5). The length of the string was typically 800 *mm*, though we also used a string 500 *mm* long. Various materials were used as spheres in the pendulum: metal, glass, ceramics, wood, rubber, plastic. The tests were carried out when the installation was covered with a Faraday cage and UHF radiation absorbing material and also without them. The installation was separated from the impulse measuring devices situated 6 *m* away by a brick wall of 0.3 *m* thickness and a list of steel with the dimensions 1 *m* $\times$ 1.2 *m* $\times$ 0.025 *m*. The measuring systems that were situated 150 *m* away were additionally shielded by a brick wall of 0.8 *m* thickness.

In order to define some other characteristics of the gravity impulse - in particular its frequency spectrum - a condenser microphone was placed along the impact line just after the glass cylinders. The microphone was connected to a computer and placed in a plastic spherical box filled with porous rubber. The microphone was first oriented with a membrane facing the direction of the discharge, then it was turned 22.5 degrees to the left, then 45 degrees to the left, then 67.5 degrees and finally 90 degrees. Several discharges were recorded in all these positions at equal discharge voltage.

3 Results

Several unexpected phenomena were observed during the experiments. The discharge in the installation corresponding to the initial set-up (Fig. 1) at room temperature in the voltage range from 100 *kV* to 450 *kV* was similar to a discharge with non-coated metal spheres and consisted of a single spark between the closest points on the spheres. When the superconductor coated sphere was cooled down below the transition temperature, the shape of the discharge changed in such a way that it did not form a direct spark between two spheres, but the sparks appeared from many points on the superconducting sphere and then moved to the corresponding electrode. When the voltage was over 500 *kV* the discharge at the initial stage had a tendency to cause some glow with the shape of a hemisphere. This glow separated from the sphere and then broke into multiple sparks which combined into more narrow bundle and finally hit the surface of the target electrode.

Repeated discharges at high voltages caused damage to the superconducting coating and partial separation of the ceramic material from the metal sphere, as the refrigeration system was not efficient enough. Also the direction of the discharge was not always repeatable. The experiments were continued with the improved variant of the installation as shown in Fig. 2 and then with the final variant of the installation as shown in Fig. 3. This new configuration allowed to increase the reproducibility of the discharge and the superconducting emitter was not damaged with high voltage. With voltage lower than 400 *kV* the discharge had the shape of a spark but when the voltage was increased to 500 *kV* the front of the moving discharge became flat with diameter corresponding to that of the emitter. This flat glowing discharge separated from the emitter and moved to the target electrode with great speed. The whole time of the discharge as defined by the photo diode was between 10^{-5} and 10^{-4} *s*. The peak value of the current at the discharge for the maximum voltage ($2 \cdot 10^6$ *V*) is of the order of 10^4 *A*.

It was found that high voltages discharges organized through the superconducting

Table 1: Emitter N. 2. Influence of high voltage discharges on the deflection of the pendulum. Experimental data are the average of 12 measurements. The standard deviation of the single data is between 5 and 7 %.

Voltage (kV)	Δl (mm)	Δh (mm)	Estimated ΔE ($J \cdot 10^{-4}$)
500	56.5	2.0	3.6
750	91.3	5.2	9.5
1000	110.4	7.7	13.9
1250	123.0	9.5	17.3
1500	131.6	10.9	19.8
1750	137.6	11.9	21.7
2000	142.0	12.7	23.1

emitter kept at the temperature of 50-70 K were accompanied by a very short pulse of radiation coming from the superconductor and propagating along the axis line connecting the center of the emitter and the center of the target electrode in the same direction as the discharge. The radiation appeared to penetrate through different bodies without any noticeable loss of energy. It acted on small interposed mobile objects like a repulsive force field, with a force proportional to the mass of the objects. As the properties of this radiation are similar to the properties of the gravity force, the observed phenomenon was called a gravity impulse.

In order to investigate the interaction of this gravity impulse with various materials, several tests were carried out, with pendulums and microphones, as described in the experimental part. The deflection of the pendulum was observed visually (see Fig. 5) and the corresponding Δl value was measured as a function of the discharge voltage. The correlation between the discharge voltage and the corresponding deflection of the pendulum as measured for two different emitters is listed in Tables 1, 2. Each value of Δl that is given in the table represents the average figure calculated from 12 discharges. A rubber sphere with a weight of 18.5 grams was used as material of the pendulum for the data listed in Tables 1, 2. The deflection caused an alteration in the potential energy of the pendulum which was proportional to Δh as shown in the table. A graphic illustration of this dependence for two different emitters is given in Fig. 6.

Both emitters, N. 1 and N. 2, were manufactured using the same OCMTG technology, but the thickness of the superconducting layer was equal to 4 mm for the emitter N. 1 and 8 mm for the emitter N. 2. Emitter N. 2 could be magnetized to a much higher value. The thickness of the normal conducting layer has a smaller influence on the force of the gravity impulse, but for better results the thickness should be bigger than 5 mm .

It was found that the force of the impact on pendulums made of different materials does not depend on the material but is only proportional to the mass of the sample. Pendulums of different mass demonstrated equal deflection at constant voltage. This was proved by a large number of measurements using spherical samples of different mass and

Table 2: Same for Emitter N. 1.

Voltage (kV)	Δl (mm)	Δh (mm)	Estimated ΔE ($J \cdot 10^{-4}$)
500	40.0	1.0	1.8
750	70.9	3.2	5.7
1000	85.3	4.6	8.3
1250	94.6	5.6	10.2
1500	100.8	6.4	11.6
1750	104.7	6.9	12.5
2000	107.1	7.2	13.1

diameter. The range of the employed test masses was between 10 and 50 grams. It was also found that there exist certain deviations in the force of the gravity impulse within the area of the projection of the emitter. These deviations (up to 12-15% max) were found to be connected with the inhomogenities of the emitter material and various imperfections of the crystals of the ceramic superconductor, and with the thickness of the interface between superconducting and normal conducting layers.

Measurements of the impulse taken at close distance (3-6 m) from the installation and at the distance of 150 m gave identical results, within the experimental errors. As these two points of measurements were separated by a thick brick wall and by air, it is possible to admit that the gravity impulse was not absorbed by the media, or the losses were negligible.

The force “beam” obtained with the latest experimental set-up does not appear to diverge and its borders are clear-cut. However, considerable efforts were necessary in order to concentrate the radiation and reach a good reproducibility. As mentioned above, the direction emission always coincides with the direction of the discharge. In the initial experiments (with the Van den Graaf generator), the direction of the beam varied, depending on the direction of the discharge, as the sparks moved to different points on the superconducting sphere. Later it was found that the magnetic field created by the solenoid wound around the chamber is able to concentrate the discharge and to direct it to the same area on the superconducting electrode.

The bi-layered emitters used in this experiment were mainly of two types. The first one was obtained after Stage 3 and had a structure typical for multiple-domain levitators with well crystallized and oriented grains of the superconducting layer. The second type was made by the material obtained after Stage 4 and consisted of densely packed non oriented polycrystalline structure in both layers. The superconducting layer in both types of emitters consisted of $YBa_2Cu_3O_{7-y}$ orthorhombic superconductor with lattice parameters $a = 3.89\text{\AA}$, $b = 11.69\text{\AA}$, $c = 3.82\text{\AA}$. The addition of small amounts of CeO_2 led to an improvement in the magnetic flux pinning properties of the Y123 compound. The emitter obtained by seeded MTG process had a superconducting layer with a maximum trapped field of 0.5 T at 77 K and a critical current density in excess of $5 \cdot 10^4 A/cm^2$. The transition temperature varied from 87 to 90 K with a transition width of about 2 degrees. The normal conducting layer had crystal lattice parameters close to those of the super-

conductor: $a = 3.88\text{\AA}$, $b = 11.79\text{\AA}$, $c = 3.82\text{\AA}$. Both layers demonstrated high electrical conductivity (over 1.5 Sm) at room temperature and the $Y_{1-x}Re_xBa_2Cu_3O_{7-y}$ layer was a normal conductor above 20 K .

In general the emitters obtained by seeded OCMTG were much more efficient than the sintered bi-layered emitters and allowed to obtain a much stronger radiation impulse, contained by the projection of the emitter. The sintered bi-layered emitters had much lower values of the trapped magnetic field and this yielded bigger energy dissipation and a weaker gravity impulse. The only advantage of the sintered emitters is that a weak impulse effect is always present, probably because the diffusion between the layers is limited. The emitters with oriented crystal structure (after seeded MTG) can be easily spoiled if the interface thickness between the two layers reaches a certain value, therefore the temperature and time parameters should be monitored carefully in order to limit the interaction between the two layers. It was found that the seeded crystal growth should be stopped before it reaches the interface region.

It was also found that the gravity impulse was to some extent proportional to the magnetic field inside the superconductor, which was created using a small solenoid during cooling down to liquid nitrogen temperature. Therefore, at recent stages of the experiment the solenoid was replaced by a powerful permanent NdFeB magnet (50 MOe) with a diameter corresponding to the diameter of the emitter and a thickness of 20 mm . This disk-shaped magnet was attached with one surface to the cooling tank and with another surface to the ceramic emitter.

The response recorded by the microphone has the typical behavior of an ideal pulse filtered by the impulse response of a physical low pass system with a bandwidth of about 16 kHz , attributed to the microphone (Fig. 7). In spite of the filtering, the relative energy of the pulses can be measured as a function of the angle of the normal to the diaphragm respect to the axis of propagation of the force.

Relative pulse amplitude with energies averaged over four pulses per angle are shown in Fig. 8 and are in agreement with a possible manifestation of a vector force acting directly on the membrane. No signal has been detected outside the impact region.

4 Discussion

(a) Capacitance of the emitter. Current at the discharge.

High voltage discharges like those described in Sections 2, 3 are well known in the literature. They do not require pre-ionisation, provided the electric field between the electrodes is sufficient to cause avalanche ionisation. However, the presence of a superconducting electrode causes some difference in the form and colour of the crown and of the sparkle, with respect to discharges between normal electrodes.

We recall that for the maximum voltage ($2 \cdot 10^6\text{ V}$) the peak value of the current is of the order of 10^4 A , and the duration of the discharge varies between 10^{-5} and 10^{-4} s . This implies a total negative charge Q on the emitter, just before the discharge, up to 0.1 C . The associated electrostatic energy is $U = QV/2 \sim 10^5\text{ J}$.

If the emitter was made of a normal conductor, its capacitance could be at most $10^{-10} F$ (for an estimate one can consider the capacitance of a sphere, namely $C \sim 10^{-10} \cdot R$ in SI units, where R is the radius). The above value for Q implies a much higher effective capacitance, of the order of $10^{-7} F$.

During the discharge an intense super-current flows from the superconducting electrode towards the ionised gas. After the superconducting charge carriers leave the negative electrode, pairs are broken and electrons are captured by the helium ions which are striking the electrode. We thus have a peculiar kind of superconductor-normal junction. Another junction is that between the superconducting emitter and the normal metallic plate.

From the theoretical point of view, these junctions can be described by Ginzburg-Landau models without specific reference to the microscopic theory. A typical time scale for the time-dependent Ginzburg-Landau equation in YBCO is of the order of $10^{-8} s$ [42], much smaller than the discharge time. This suggests that a quasi-stationary approximation could be adequate. The situation is however complicated by the following circumstances:

(1) In anisotropic materials like HTC's the Ginzburg-Landau equation involves an order parameter with non-trivial symmetry and the pairs are thought to possess intrinsic angular momentum.

(2) The transport current is very intense. In type-II superconductors, transport currents are associated to non-reversible displacement of flux lines, and this effect in turn depends strongly on the pinning properties of the material.

(3) The emitter is subjected to a strong external magnetic field during the discharge.

More efforts are therefore necessary, both on the experimental and theoretical side, for a complete understanding of the state of the superconducting emitter during the discharge.

(b) Evidence of the gravitational-like nature of the effect.

The gravitational-like nature of the effect is best demonstrated by its independence on the mass and composition of the targets (see Section 3). We are aware, of course, that gravitational interactions of this kind are absolutely unusual (see Sections 4.1, 4.3). For this reason, several details of the experimental apparatus were designed with the explicit purpose of reducing spurious effects like mechanical and acoustic vibrations much below the magnitude order of the observed anomalous forces.

Indirect evidence for a gravitational effect comes from the fact that any kind of electromagnetic shielding is ineffective. Note that if one can explain in some way the anomalous generation of a gravitational field in the superconductor, its undisturbed propagation follows as a well-known property of gravity (see Section 4.2). Indirect support for the gravitational hypothesis also comes from the partial similarity of this apparatus to that employed by Podkletnov for the stationary weak gravitational shielding experiment [1].

If the effect is truly gravitational, then the acceleration of any test body on which the impulse acts should be in principle independent on the mass of the body. Suppose that l is the length of a detection pendulum and g is the local gravitational acceleration. Let d be the half-amplitude of the oscillation. Let t be the duration of the impulse, and F its strength. F has the dimensions of an acceleration (m/s^2) and can be compared with g .

One easily computes that the product of the strength of the impulse by its duration is

$$Ft = \sqrt{2gl[1 - \sqrt{1 - (d/l)^2}]} \quad (1)$$

If $d \ll l$, this formula can be simplified, and we have approximately $Ft \sim \sqrt{(g/l)d} = 2\pi d/T$, where T is the period of the pendulum. With the data of Table 1, taking $t = 10^{-4}$ s, one finds $F \sim 10^3 g$.

Here, however, we encounter a conceptual difficulty. Suppose to place on the trajectory of the beam a very massive pendulum (say, 10^3 Kg). If the effect is gravitational, then the acceleration of a test mass should not depend on its mass. However, it is clear that in order to give this mass the same oscillation amplitude of the small masses employed in the experiment, a huge energy amount is necessary, which cannot be provided by the device. Therefore the effect would seem to violate the equivalence principle. Considering the back-reaction is probably necessary, namely the fact that the test mass exerts a reaction on the source of the impulse. This reaction is negligible as long as we use small test masses.

(c) Anomalous features of the observed “radiation”.

Independently from any interpretation, the abnormal character of this radiation appears immediately clear. It appears to propagate through walls and metal plates without noticeable absorption, but this is not due to a weak coupling with matter, because the radiation acts with significant strength on the test masses free to move. Furthermore, this radiation conveys an impulse which is certainly not related to the carried energy by the usual dispersion relation $E = p/c$. A corresponding energy transfer to the test masses is not in fact observed (unless one admits perfect reflection, which seems however very unlikely).

The denomination “radiation” is actually unsuitable, and one could possibly envisage an unknown quasi-static force field. In this way one could explain why an impulse is transmitted to the test masses. However, it is hard to understand how such a field could be so well focused.

4.1 A possible theoretical explanation. Basic concepts.

The following Sections contain an informal introduction to a theoretical model originally developed by one of the authors [18, 19, 20, 21, 22] in order to explain the weak gravitational shielding effect by HTC superconductors [1, 2]. We suggest that this theory may be a starting point for the explanation of the impulsive gravitational-like forces described in the present paper.

The quantum properties of the gravitational field play an essential role in this model. These properties are not adequately known yet, therefore the proposed model is still in a preliminary development phase and its predictive capabilities are quite limited. Its primary merit is to envisage a new dynamic mechanism which could account for the effect. However, a full theory which justifies the model does not exist so far. This should be, in fact, a theory of the interaction between gravity (including its quantum aspects), and a particular state of matter - that of a HTC superconductor - which in turn is not completely known.

The glossary below ¹ collects some keywords and their equivalent, also for a better orientation in the cited works.

(a) Weakness of the standard coupling with gravity. Anomalous coupling.

The standard coupling of matter to gravity is obtained from the Einstein equations by including the material part of the system into the energy-impulse tensor. Since the coupling constant is G/c^4 , very large amounts of matter/energy, or at least large densities, are always necessary in order to obtain gravitational effects of some importance. This holds also at the quantum level, in weak field approximation. It is possible to quantize the gravitational field by introducing quantum fluctuations with respect to a classical background, and then calculate the graviton emission probabilities associated to transitions in atomic systems. These always turn out to be extremely small, still because of the weakness of the coupling.

What we proved in our cited works is that a peculiar “anomalous” coupling mechanism exists, between gravity and matter in a macroscopic quantum state. In this state matter is described by a collective wave function. Also in this state the energy-impulse of matter couples to the gravitational field in the standard way prescribed by the equivalence principle. However, the new idea is that besides this standard coupling there is another effect, due to the interference of the Lagrangian L of coherent matter with the “natural” vacuum energy term $\Lambda/8\pi G$ which is present in the Einstein equations. The two quantities have in fact the same tensorial form but possibly different sign, and it turns out that their interference can lead to a dramatic enhancement of vacuum fluctuations.

(b) Contribution of a quantum condensate to the vacuum energy density.

It is well known that the “natural” vacuum energy, or cosmological term, is very small. Until recently, it was thought to be exactly null. The most recent observations give a value different from zero, but in any case very tiny [23, 47], of the order of $0.1 J/m^3$. This is usually supposed to be relevant at cosmological level, in determining the curvature and expansion rate of the universe on very large scales.

The observed value can be regarded as the residual of a complex interplay, in a still unknown high energy sector of particle physics, between positive and negative vacuum energy densities. According to [24], the observed residual should also be scale-dependent and this dependence could appear most clearly at length scales corresponding to the mass of the lightest particles like neutrinos or unidentified scalars.

¹ *Cosmological term = vacuum energy density:* see (b).

Lagrangian L = action density. Minimization of the action of a system gives its dynamical equations.

Quantum condensate in a superconductor: ensemble of the Cooper pairs, with collective wave function ψ_{GL} (also called an “order parameter”) supposed to obey the Ginzburg-Landau (GL) equation. In the non-relativistic limit, the Lagrangian density of the condensate is just the opposite of the GL free energy density.

Zero-modes of the Einstein action = gravitational dipolar fluctuations: see (c).

Critical region: region of the condensate with positive Lagrangian density. According to the GL theory, it can only exist for constant solutions of the GL equation or in the neighbourhood of a local relative maximum of the Cooper pair density $|\psi_{GL}|^2$. See (f).

Noise source = density matrix: a formal way to express the fact that inside a critical region the gravitational field undergoes strong dipolar fluctuations and therefore takes on at random values h_i^2 with probability ξ_i . See (h), (i).

In certain conditions, the action density of a Bose condensate in condensed matter can be greater than the cosmological term, but it is nonetheless very small. Its effect on the local space curvature is absolutely negligible.

(c) The gravitational zero modes and the polarization of the gravitational vacuum.

Why so do we think that the interference of these two terms, which are in any case very small, can lead to some observable gravitational effect? Because we proved the existence of gravitational field configurations in vacuum, for which the value of the pure Einstein action (without the cosmological term) is exactly null, like for flat space. We called these configurations “zero modes of the Einstein action”. At the quantum level, where fluctuations are admitted with respect to flat space, they are free to grow unrestrained. In a certain sense, the quantum space-time is unstable and has a natural tendency not to stay in the flat state, but to fall into these configurations, with a definite probability. They are virtual configurations, in the sense that they are permitted in the Feynman integral describing the quantum theory. In the Feynman integral all the possible configurations are admitted - not only those satisfying the field equations - each weighed with probability equal to the exponential of its action divided by $\hbar$. All these configurations (fluctuations) take part in defining the state of the system.

The zero-modes of the Einstein action are in all the same as fields produced by mass dipoles. In nature, mass dipoles do not exist as real sources. Nevertheless, the dipolar fluctuations mathematically have such a form. Being vacuum fluctuations, they are invariant under translations and Lorentz transformations, they are homogeneously allocated in space and at all length scales. That is, the dipolar fluctuations correspond to the fields produced by dipoles of various sizes, distributed in a uniform way. They can only show their presence if, in some way, their homogeneity and uniformity are broken. We are in presence of an analogue of the vacuum polarization in quantum electrodynamics. In that case, virtual couples of electrons/positrons pop up in the vacuum, and then quickly annihilate, generating uniform fluctuations. It is well known that these virtual processes must be taken into account, because they affect, for instance, the bare charge of the particles and their couplings. However, quantum corrections are, as a rule, very small in quantum electrodynamics.

It is important to be aware that the gravitational dipolar fluctuations we are talking about are neither the ordinary fluctuations of perturbation theory nor the well known “spacetime foam” fluctuations, which appear in quantum gravity at very short distances. Their nature is completely different. Although their intensity can be very large, they have null action, thanks to the compensation of positive and negative curvature between adjacent zones of space-time. The dipolar fluctuations are not zero-modes of the Lagrangian, but of the action. Their existence is possible thanks to the fact that the gravitational Lagrangian is not defined positive, unlike the Lagrangian of electromagnetic and gauge fields.

(d) The vacuum energy cuts the gravitational zero-modes to a certain level.

Let us go back to the cosmological term. One finds that it is related to the dipolar fluctuations, because it sets an upper limit on their amplitude. The contribution of a

dipolar fluctuation to the cosmological term is typically of the form [21]

$$\Delta S = \Lambda \tau M r^2 Q \quad (2)$$

where natural units are used ($\hbar = c = 1$); τ is the duration of the fluctuation, M is the order of magnitude of the virtual +/- masses, r their distance and Q is an adimensional function which depends on the detailed form of the dipole. If $\Delta S \gg 1$, then the fluctuation is suppressed.

With an electromagnetic analogy (not to be pushed too far) we could then say that the cosmological term sets the gravitational polarizability of free space. One expects that in a full non-perturbative theory of quantum gravity the bare value of the gravitational constant G should be renormalized by this effect. However, as long as the cosmological term is uniform in space and time, there are no observable consequences. On the other hand, if the vacuum energy density changes locally, this can have observable effects. In particular, if there are positive local contributions which subtract from the natural density, the result can be a local increase in the gravitational polarizability.

(e) The anomalous coupling is only active when the condensate is in certain particular states.

Our model can also explain why only certain superconductors in certain conditions show evidence of anomalous coupling with the gravitational field. The key point is not simply the presence of a quantum condensate, nor the density of this condensate. In fact, if this was the case, anomalous gravitational effects would be observed also with low temperature superconductors, or with superfluids. But even in the static Podkletnov experiment, only in certain conditions observable effects are obtained, and their intensity is variable.

Therefore the presence of the condensate is not sufficient to cause the effect. What are the necessary conditions? The anomalous contribution to the cosmological term is given by the Lagrangian density of the condensate, according to the following equations. Consider a scalar field ϕ interacting with gravity (we use units $\hbar = c = 1$; SI units will be restored in eq. (12)). The interaction action is obtained from the energy-momentum tensor:

$$L = \frac{1}{2}(\partial_\alpha \phi \partial^\alpha \phi - m^2 |\phi|^2) \quad (3)$$

$$T_{\mu\nu} = \Pi_\mu \partial_\nu \phi - g_{\mu\nu} L = \partial_\mu \phi^* \partial_\nu \phi - g_{\mu\nu} L \quad (4)$$

$$S_{interaction} = \frac{1}{2} \int d^4x \sqrt{g(x)} T^{\mu\nu}(x) h_{\mu\nu}(x) \quad (5)$$

To lowest order in $h_{\mu\nu}$ the interaction action can be rewritten as

$$S_{interaction} = \frac{1}{2} \int d^4x (h_{\mu\nu} \partial^\mu \phi^* \partial^\nu \phi - \text{Tr} h L) \quad (6)$$

On the other hand, the cosmological term is (still to lowest order in $h_{\mu\nu}$ and expanding $\sqrt{g} = 1 + \frac{1}{2} \text{Tr} h + \dots$)

$$S_\Lambda = \frac{\Lambda}{8\pi G} \int d^4x \left(1 + \frac{1}{2} \text{Tr} h \right) \quad (7)$$

Therefore the sum of the two terms can be rewritten as

$$S_{interaction} + S_{\Lambda} = \frac{1}{2} \int d^4x h_{\mu\nu} \partial^{\mu} \phi^* \partial^{\nu} \phi + \frac{1}{2} \int d^4x \text{Tr} h \left(\frac{\Lambda}{8\pi G} - L \right) \quad (8)$$

We see that to leading order the coupling of gravity to ϕ gives a typical source term ($h_{\mu\nu} \partial^{\mu} \phi^* \partial^{\nu} \phi$) and subtracts from Λ the local density $8\pi GL(x)$. This separation is arbitrary, but useful and reasonable if the Lagrangian density is such to affect locally the “natural” cosmological term and change the spectrum of gravitational vacuum fluctuations corresponding to virtual mass densities *much larger than the real density of ϕ* .

For example, suppose that ϕ represents a condensate with the density of ordinary matter ($\sim 1 \text{ g/cm}^3$). At the scale $r \sim 10^{-4} \text{ cm}$, $\tau \sim 10^{-4} \text{ s}$, with the observed value of Λ , the upper bound on the virtual source density is $\sim 10^{17} \text{ g/cm}^3$, which is much larger than the real density. If L is comparable to $\Lambda/8\pi G$ in some region, an inhomogeneity in the cut-off mechanism of the dipolar fluctuations will follow, and this effect could exceed by far the effects of the coupling ($h_{\mu\nu} \partial^{\mu} \phi^* \partial^{\nu} \phi$) to real matter.

The value of the Lagrangian depends on the state the condensate is in, and more exactly on the macroscopic wave function ψ_{GL} of the Cooper pairs. The problem of finding the wave function in given experimental conditions is still open. From the wave function one can compute the Lagrangian, and then the local contribution of the superconductor to the vacuum energy, and its ability to produce anomalous gravitational coupling.

(f) L subtracts from Λ only where the density $|\psi_{GL}|^2$ has a local maximum.

The Lagrangian L in eq. (3) is the Klein-Gordon Lagrangian which describes a relativistic free scalar field. In order to relate it, in the low energy limit, to the Ginzburg-Landau (GL) free energy of superconductors [25] one makes the standard transformation

$$\psi_{KG}(\mathbf{x}) = e^{imt} \phi(x) \quad (9)$$

where m is the Cooper pair mass. Then one turns to the GL wave function by re-normalizing ψ_{KG} as follows

$$\psi_{KG}(\mathbf{x}) = \sqrt{m} \psi_{GL}(\mathbf{x}) \quad (10)$$

This normalization corresponds to the standard relation $|\psi_{GL}(\mathbf{x})|^2 = \rho(\mathbf{x})$, where ρ is the density of Cooper pairs. Finally, the free Lagrangian is generalized by adding a quadratic and a quartic interaction term and the minimal electromagnetic coupling. In this way one finds

$$L = -\frac{1}{2m} | -i\nabla\psi + 2e\mathbf{A}\psi |^2 - \alpha\psi^*\psi - \frac{1}{2}\beta(\psi^*\psi)^2 \quad (11)$$

This is the Lagrangian density to be inserted into eq. (8) as contribution to the vacuum energy density. It is the opposite of the GL free energy density [?], as expected. For wave functions which satisfy the wave equation derived from (11), the expression of L simplifies to

$$L = -\frac{1}{2m} \left[\hbar^2 (\nabla\rho)^2 + \hbar^2 \rho \nabla^2 \rho - m\beta\rho^2 \right] \quad (12)$$

where $\hbar$ has been re-introduced to allow for a better numerical estimate.

We recall [26] that the α and β coefficients depend on the absolute temperature T . The coefficient β is always positive and approximately constant near T_c ; α is negative for $T < T_c$ and near T_c behaves like $const.(T - T_c)$. The ratio between α and β is given by the relation $n_p = -\alpha/\beta$, where n_p is the average density of pairs in the material. Finally, β is linked to the value of the Ginzburg-Landau parameter $\kappa = \lambda/\xi$ by the relation $\kappa^2 = m^2\beta/(2\mu_0\hbar^2e^2)$. Two further important points which should be taken into account are (i) the boundary conditions on ψ_{GL} at the superconductor/ normal conductor and superconductor/ionized gas interfaces; (ii) the intrinsic anisotropy of HTC materials, which actually also affects the form of the GL free energy.

The relative importance in eq. (12) of the terms with the gradients and the term proportional to β depends on the length scale at which the variations of ψ_{GL} can occur. If, as usual for Type II and HTC superconductors, this scale is of the order of $10^{-8} m$ or less, the terms with the gradient dominate.

It is straightforward to check that the sign of L is negative, except for two types of configurations:

(1) For the constant solutions of the Ginzburg-Landau equation in the absence of external field, namely $\rho(\mathbf{x}) = n_p$. The corresponding constant Lagrangian density is $L_1 = \frac{1}{2}\beta n_p^2$.

(2) For regions of the condensate where $\rho\nabla^2\rho$ is negative and greater, in absolute value, than $(\nabla\rho)^2$. It is straightforward to check that these are regions located around local density maximums, or more generally about lines and surfaces where the first partial derivatives of ρ are zero and the second derivatives are negative or null. The Lagrangian density at a maximum is $L_2 \sim \frac{1}{2m}\rho|\rho''|$. If the maximum is sharp, L can be much larger than for constant solutions. Configurations of this kind are characteristic of solutions of the Ginzburg-Landau equation with strong magnetic flux penetration [27].

Now we make some numerical estimates of L . Assuming for YBCO $\rho \sim 10^{27}m^{-3}$, $\xi \sim 10^{-9} m$, $\kappa \sim 10^2$, we obtain for the configurations (1) and (2) densities $L_1 \sim 10^4 J/m^3$ and $L_2 \sim 10^7 J/m^3$, respectively. With reference to our experiment we must explain, on the basis of these figures, why anomalous coupling at the emitter takes place, but only at the moment of the discharge and in presence of strong magnetic flux penetration.

We remind that the vacuum energy density acts as cut-off for the dipolar fluctuations, so that their maximum amplitude A is inversely proportional to Λ . Therefore in presence of a local contribution by the superconductor we have

$$A \propto \frac{1}{|\Lambda/8\pi G - L|} \quad (13)$$

So an amplification of the fluctuations is possible when L has the same sign as Λ . From the experimental observations it is clear that a negative value of L does not give the necessary conditions. In fact, in that case anomalous coupling would be observed every time there are strong density gradients in the superconducting material - which occurs almost always. From this we obtain a first piece of information about the value of Λ at atomic scale (otherwise unknown): it must be positive. $\Lambda/8\pi G$ must furthermore be much larger than L_1 , because a constant density does not give observable anomalous effects

either. In conclusion, $\Lambda/8\pi G$ must be larger than L_2 , and the amplitude A of the dipolar fluctuations increases as the local value of L approaches it from below.²

This can happen in presence of strong magnetic flux penetration (Point 2 above), but that requisite is not sufficient: the presence of a strong transport current is also necessary. In fact, with strong flux penetration, the density ρ is depressed. The current appears like a means to obtain at once a large ρ and a large value of ρ'' in correspondence of the maximums. Indeed, in inhomogeneous materials like HTC's, a very intense transport current inevitably forces a large density in certain regions. In the case of the weak gravitational shielding [1] the transport current is mostly due to the accelerated rotation of the disk [28]. In the present case it is due to the discharge.

(g) The anomalous coupling inside the condensate modifies the field also outside.

Summarizing, we can say that in particular conditions a quantum condensate is able to modify locally the cosmological term of the gravitational action. In turn, the cosmological term fixes the cut level of the dipolar fluctuations, and so the local gravitational vacuum polarizability. Therefore an anomalous coupling of the condensate with the gravitational field is observed. This coupling can be abnormally strong, due to the large amplitude of the vacuum fluctuations. It is a kind of coupling that completely eludes the standard form and so is not proportional, through the G/c^4 constant, to the energy-impulse content of the condensate.

The next question is: how is the gravitational field modified inside the condensate and in its neighbourhood? In other words, let us suppose that the gravitational field displays a much higher level of dipolar fluctuations in some regions of the condensate. What is the consequence for the global behaviour of the field? For instance, with reference to the static experiment, why is there a noticeable reduction of the terrestrial field above the disc? We can say that in that case there is a big gravitational source - the earth - producing a uniform field in the region of interest, according to the usual classical field equations. Into these equations, however, we must also introduce a kind of "random source" located in the condensate. This affects the field also outside.

(h) The modified field equation contains an arbitrary constant.

We have proposed to introduce into the gravitational field equations a term representing a random source located in the condensate. This procedure has some intrinsic arbitrariness. The intensity of the source is arbitrary, too, and cannot be obtained from the ratio between the energy density of the condensate and the "natural" vacuum energy density. In fact, it is true that this ratio allows us to determine the maximum amplitude of the dipolar fluctuations. However, the probability of these fluctuations, and so their weight with respect to the external configurations, is still an unknown element of the theory. We know that certain field configurations give a null contribution to the pure Einstein

²The density L_2 can be compared with that obtainable for an electromagnetic field alone - which can also be regarded as "coherent matter" in this context. The electromagnetic energy density is proportional to $(\mathbf{E}^2 + \mathbf{B}^2)$, but the action density is proportional to $(\mathbf{E}^2 - \mathbf{B}^2)$, therefore only an electrostatic field has the right sign. But even with a field strength of $3 \cdot 10^6$ V/m, one obtains a density of 100 J/m³, definitely lower.

action and can grow up without limit, and we can determine the cut-off amplitude due to the intervention of the cosmological term; however, the probability that these fluctuations really happen is a feature of the quantum theory, which is not known yet. In principle, it would be possible to write a functional integral containing all the involved fields, the test masses etc., evaluate it and obtain everything. In practice, what we can do with such an integral is only a weak field expansion about the minimum of the action.

In conclusion, if we represent the gravitational fluctuations in the quantum condensate as a random source, the intensity of this source must be inserted as a parameter which is fixed “a posteriori” from the experimental data. This should not be unexpected. The experimental observations described in this work are absolutely new and unprecedented. They inform us about a sector of the theory which is otherwise unknown. The validity of our model consists of suggesting a new interaction process, while avoiding contradictions with known facts, and while giving the freedom to fix a new coupling constant.

(i) The modified field equation must be able to describe the observed phenomenology.

After modelling the effect of the fluctuations on the external field (for instance, as random source with a certain strength), we are able to verify the consistency and correctness of the procedure by calculating this field and comparing the result to the data - not only as intensity but also as shape. For instance, we know that in the static experiment a “shielding cylinder” was observed which extended far above the superconducting disc and showed net borders, without diffraction. Obtaining this characteristic from the field equations modified by the anomalous coupling is all but trivial. The observed field configuration is furthermore clearly not conservative. (This can be understood remembering that there is a source term in the equation.) Nonetheless, we succeeded in [20] in obtaining a result of this kind (see also [29]).

(j) Euclidean and Lorentzian formulation of the anomalous coupling and of the modified action.

From the technical point of view, the general program outlined above has been implemented in the Euclidean (or imaginary-time) version of quantum gravity [18, 19, 20], and more recently in the standard Lorentzian version [21].

The occurrence of the dipolar fluctuations and the cut-off role of the vacuum energy density are most clearly and safely exhibited in the Lorentzian formalism. On the other hand, the Euclidean formulation is reliable and more suitable for perturbative calculations of the modified field equations.

The Lorentzian formulation is indispensable for the latest developments (calculation of the low-energy limit of L and determination of its sign as a function of ρ).

4.2 Possible interpretation of the gravitational-like impulse at the discharge

We focus now our attention on the new, puzzling effects described in the experimental part of this paper, and partially analysed at the beginning of this Section. We cannot offer any

quantitative interpretation of these effects yet, so we shall limit ourselves to an hypothesis based on our previous work on the static effect.

(a) From the static to the transient effect: the virtual dipoles emit virtual radiation.

We have seen that the observed impulse can neither be described as a real radiation, nor as a quasi-static field. These are the two types of field configurations which are predicted by any classical theory.

However, we also saw that the weak gravitational shielding effect can be explained introducing the concept of anomalous dipolar quantum fluctuations induced by the condensate. These fluctuations locally increase to observable levels the gravitational vacuum polarizability.

In the transient case, the virtual dipolar fields are rapidly varying in time, because the critical conditions in the quantum condensate are produced only for a short time at the discharge. Therefore it is natural to expect that in this case the formation of virtual dipoles is accompanied by the emission of virtual dipolar radiation.

(b) In quantum mechanics every interaction is equivalent to an exchange of virtual radiation.

Let us recall the concept of “virtual radiation” as intermediate state of a quantum process. In quantum mechanics, every interaction is thought to take place through the exchange of virtual particles - photons, gauge bosons, gravitons. This is especially clear in scattering processes, but also the static interaction potential can be written as an integral over time and four-momentum of the propagator of a mediating virtual particle [30]. In this integral, all values of energy-momentum are included, not only the “on-shell” values satisfying the condition $E = p/c$ which is typical of real photons and gravitons. This is possible just because the mediating particles are virtual, i.e. so short-living that the Heisenberg principle allows for a large indetermination in their energy. In fact, the static force obtained as a sum of virtual processes is very different from the effect of a collection of free photons or gravitons.

It is also possible to compute along these lines the quantum corrections to the classical force. To this end, one includes in the sum some less probable processes, involving the exchange of several mediating particles at the same time, or the creation-annihilation of virtual pairs, and so on.

(c) The impulse at the discharge is made of off-shell gravitons.

In order to explain the weak gravitational shielding effect we hypothesised an anomalous strong quantum correction to the field of the earth. In the transient case, on the other hand, all the emitted “radiation” should be regarded as a quantum effect. The observed impulsive force could be the effect of virtual processes in which:

1. The intense supercurrent flowing across the superconducting cathode produces critical gravitational regions, with strong dipolar vacuum fluctuations. The necessary conditions are those discussed in Section (4.1-f).

2. These fluctuations emit a beam of virtual off-shell gravitons with $E \ll p/c$. The direction of the beam is sharply defined by momentum conservation. Whatever the exact microscopic mechanism, the momentum carried by the virtual radiation can only originate from that of the Cooper pairs entering the critical regions, i.e. from the momentum of the supercurrent. This is in agreement with the fact that if the impact direction of the discharge changes (like in the earlier set-up, see 3), also the direction of the emitted radiation changes.

3. When the beam hits a mobile target, it conveys an impulse to this target. Like for usual gravitational forces (which can also be interpreted as graviton exchange, as mentioned), interposed bodies do not affect transmission.

4.3 Known effects which could be connected to the observed phenomenon.

The following concepts are often quoted to explain anomalous gravitational effects. So we summarise them quickly, even though in our case they do not fit to the observed phenomenology.

We recall that several alternative theories were proposed, in the last decades, in the attempt to “explain” and give a physical basis to spacetime and vacuum. Every one of these, to be credible, must first of all reproduce the known results of general relativity and quantum field theory. Notable examples are theories of “induced” gravity according to Sakharov’s idea [31], and string theory. It is not easy to judge if anyone of these theories can also predict, in addition, unusual effects in the presence of superconductors. Some are not developed enough to give a definite answer. Many have been proposed recently, still their authors did not envisage any anomalous coupling to matter in a macroscopic quantum state. In general, if the coupling of gravity to matter conforms to the classical Einstein equations, then the intensity of any generated gravitational field will depend only on the energy-momentum of the source multiplied by G/c^4 , so there is no chance for anomalous effects. A notable exception could be torsion theory, which predicts a coupling to quantum spin not allowed in the Einstein equations; however, as we shall see below, there are strict experimental limits on the coupling of matter to torsion. Another possibility is to consider strong quantum effects, as done in Section 4.2; in that case, we chose to start from the standard form of the classical theory.

(a) The gravitomagnetic field

Could the observed anomalous forces be due to the fact that the superconductor produces during the discharge a strong gravitomagnetic field? It is well known from general relativity that the gravitational field contains components of magnetic type, called the gravitomagnetic field. These components have the property to be produced by moving objects and to act on objects in movement. It is possible to write the Einstein field equations in weak field approximation in a form very similar to that of Maxwell equations. The important difference, with respect to the Maxwell equations for electromagnetism, is that gravitomagnetic effects are suppressed by factors $1/c$ or $1/c^2$. So they are always very small with respect to “gravitoelectric” effects - those which have a Newtonian limit. See for instance [32, 33]; in these references an analysis of the Maxwell equations for

gravity and also of the “Gravity Probe B gyroscope experiment” for detecting the Earth’s gravitomagnetic field is given.

In certain conditions the gravitomagnetic field can be repulsive. In neutrons stars it can produce a gravitational analogue of the Meissner effect. As one would expect, however, the “gravitational Meissner effect” is exceedingly weak: for instance, it has been computed that in a neutron star with a density of the order of 10^{14} g/cm^3 , the London penetration depth is ca. 12 km [34]. In the 1970s experiments were done to detect possible weight decreases of a rotor while it was rotating at very high speed [35], but conclusive results were never obtained.

(b) Gravitomagnetism and quantum spin

The aspects of the theory of quantum gravity concerning the spin are summarized, for instance, in [36]. In previous work [37] O’Connell examined the implications arising from the fact that spin contributions to the gravitational potential are as large as the spin-independent contributions for interparticle separations of the order of Compton length and also that such spin-dependent forces could be repulsive for certain spin orientations. An analysis was also carried out of the possibility of measuring gravitational spin-dependent forces in the laboratory [38]. An idea of one such experiment, as proposed in [39], is to observe a breaking of the equilibrium of a polarized body, hanging in the gravitational field, when its polarized state is destroyed. This effect, if present, is predicted to be extremely small. (See also the results by Ritter et al. [40].) Claims like those by Wallace of “antigravity” forces produced by spin orientation in nuclei [41] appear as totally unreliable today.

(c) The works by Ning Li and Torr

In a series of articles Ning Li and Torr [6] calculated the gravitomagnetic field which would be produced by a superconductor containing circulating supercurrents. According to them, in this case also the movement of the ions, which produce a current of mass, has particular importance. Also the fact that spin alignment is present would be very important. The alignment of the spin of the lattice ions would be a source of gravitomagnetic field. The objections to this model are of two types. First, the total spin amount that is possible to obtain in normal condensed matter is always very small, also in presence of alignment. Therefore, given the weak coupling with the gravitomagnetic field, one does not understand how it could reach detectable intensity. Another objection is of more technical nature. Ning Li and Torr use the Maxwell equations for gravity, which hold in weak field approximation. However, when they find that some terms of these equations “explode”, they keep this result even if it is inconsistent with the initial approximation.

Previously to the first Podkletnov experiment [1] and without reference to it, Ning Li and Torr determined another consequence of their model [7]. Not only the alignment of the spin of the lattice ions would produce a gravitomagnetic field, but in the presence of an outside applied time-dependent vector potential, this would be converted into a perceptible gravitoelectric field. Such a conversion is necessary, if one wants to apply this theory to the weak gravitational shielding, because in that case the test bodies are at rest, and so they would not respond to a gravitomagnetic field. However, this is in contrast with the

short-lived permanence of the effect also after all the outside fields are turned off. At last, we notice that Ning Li and Torr never published a work in which they try to interpret the phenomenology of the effect in terms of their model nor to explain why it is observed only with certain types of superconductors.

(d) Other models connected to gravitomagnetism

There have been proposals of alternative interpretations of gravitomagnetism in connection with the Mach principle [45]. In this context, the gravitomagnetic phenomena would achieve a greater importance. Still with reference to a Machian theory, Woodard claims to have experimentally obtained some transient fluctuations in the inertial mass of a capacitor [46]. However we will not be concerned here with these approaches, which to a large extent remained at a subjective level.

Recently Ummarino [42] tried to establish a link between the Podkletnov effect and the gravitomagnetic and gravitoelectric field, following a more standard approach, connected with the Ginzburg-Landau theory for superconductors.

(e) Theories with torsion

We now come to the theories of gravity with torsion. Could the observed phenomenology, not understandable in general relativity, be related to the existence of a torsion field? Let us first recall how the concept of torsion was born: from the idea of considering the connection (which in the metric formalism is simply a quantity derived from the metric and is symmetric with respect to a couple of indexes) like an independent quantity, with its own dynamics and, generally, not symmetric. Torsion theory is an extension of general relativity, which was investigated in great detail in the past. It is necessary in fact in order to introduce the interaction of the gravitational field with the quantum spin, and allows to connect general relativity to the usual gauge theories. After admitting the possibility of the existence of torsion, its features (for instance, its propagation), do not descend from first principles or from the geometrical structure of the theory, but from the form of the various possible terms in the action and from coupling constants fixed on the basis of experimental observations. Over the years a large amount of experimental data have been accumulated, which place strong limits on the couplings.

A picture of the current situation is for instance presented by Carroll and Field [43]. What is concluded is that the possible existence of the torsion can be of interest at the level of gravitational interactions at very short distances (Planck scale), but not at the level of laboratory experiments.

In their work Carroll and Field discuss possible actions for torsion and its interaction with matter fields like those of the standard model of particle physics. They construct a free Lagrangian from powers and derivatives of the torsion, and couple it “minimally” to matter through the covariant derivative. They find that there is only a small range of models possible without placing arbitrary restrictions on the dynamics. In these models only a single mode interacts with matter, either a massive scalar or a massive spin-1 field, and each mode is parameterised by two constants with the dimension of mass. They concentrate on the scalar theory, which is related to several proposals found in the literature and discuss what regions of parameter space are excluded by laboratory and astrophysical

data. Carroll and Field find that a reasonable expectation would be for each of the two mass parameters to be of the order of the Planck scale; such a choice is a safe distance away from the regions excluded by experiment. They conclude that, while there are reasons to expect that the torsion degrees of freedom exist as propagating fields, there is no reason to expect any observable signature from torsion.

Other “not orthodox” points of view are represented in literature [44]. But even though theories of torsion exist since a long time, no attempts to explain the phenomenology of the Podkletnov effect were ever presented.

(f) The value of G and the measurements at short distances

The fundamental characteristics of the gravitational interaction keep on being a very alive and interesting research field. We do not mean by this the consequences of gravity on the structure of the universe, and so the applications of general relativity to black holes, astrophysics etc.; we mean the basic features of the force, including the issue whether general relativity is an adequate and complete description of it. We recall that only two predictions of general relativity have not been verified yet, namely the existence of gravitational waves and of gravitomagnetic fields. There are furthermore several current experiments to detect possible violations of the equivalence principle. Up to now no contradiction has ever been observed with respect to the predictions of general relativity [47].

The precision with which the value of G is known is clearly unsatisfactory compared to the precision with which the other fundamental physical constants are known. This is also due to the fact that while the definition of the other fundamental constants relies on microscopic experiments performed with high precision devices, for the G constant it is necessary to use more or less sophisticated versions of the Cavendish experiment. In particular, we do not know the behaviour of gravity at short distances (millimeters or less). According to Gillies [48], in the second half of 1900 more measurements of G were made than ever before. Some discrepancies were observed in recent times with respect to the best official value fixed in 1982.

The value of G has been called into question by new measurements from respected research teams in Germany, New Zealand, and Russia [49]. The new values disagree wildly. For example, a team from the German Institute of Standards obtained a value for G that is 0.6% larger than the accepted value; a group from the University of Wuppertal in Germany found a value that is 0.06% lower and one at the Measurement Standards Laboratory of New Zealand measured a value that is 0.1% lower. The Russian group found a space and time variation of G of up to 0.7%. The collection of these new results suggests that the uncertainty in G could be much larger than originally thought. This controversy has spurred several efforts to make a more reliable measurement of G .

A recent theoretical prediction suggests that gravity penetrates extra, compact dimensions so that the gravitational inverse square law must be modified at short ranges (less than 1 *mm*). Arkani-Hamed, Dimopoulos, and Dvali [50], have offered this as an explanation of the hierarchy problem. A team at the university of Washington is doing new measurements in order to check this, but results are negative up to now [51].

(g) The anomalous acceleration of the Pioneer and scalar-tensor theories

Let us now pass from the shortest distances at which it is possible to observe gravitational interactions in the laboratory, to the largest. Surprising results were obtained recently by the observation of the motion of the Pioneer space probes [53]. Direct measurements are possible thanks to the radio signals transmitted by the spacecrafts, which give precise information about their position, speed and acceleration. From the analysis of the data a residual acceleration was found, not explainable through the usual orbit tracking models. Some proposals for a theoretical explanation of the phenomenon were presented. One of these [54] calls for the existence, in addition to Einstein's gravitational field, of a scalar field which, supposed it has certain properties, could lead to the observed effect. This field could also be responsible for the rotation anomalies observed in the galaxies, because it gives a modification of the behaviour of gravity at large distances. The cited model belongs in practice to a wide group of extensions of the standard theory of gravitation [52], which originate from the Brans-Dicke model and in more recent times refer to string theory and to the so-called dilaton field.

(h) Gravitational anomalies at solar eclipses

There is a long history of claims of possible anomalous changes of gravity during sun eclipses. These would be different from tidal changes, which are well known and calculable with precision, and could show that some kind of shielding of the solar attraction by the moon exists, at the moment when it steps in between the earth and the sun. The data, however, are quite contradictory [55].

The original experiments by Allais, in which the change of the oscillation period of a pendulum was observed, seemed to imply a decrease in g of about 1/100 of the solar gravity. The consequence would be an apparent increase of the terrestrial attraction of about one part in a million. During the eclipse of 2000 a net of observers with pendulums and gravimeters was organised by initiative of the NASA, in order to observe possible changes; the definitive results are not available yet. A work was published in 2000 by a Chinese team, with reference to the eclipse of 1997 [56], in which data measured with a high precision gravimeter are reported. Also in this case, some anomalies were observed at the eclipse, but with features very different from those reported before. There is a noticeable decrease of the terrestrial attraction, that is, an apparent anti-screening of the solar gravity. The shielding factor is much smaller than the one declared by Allais, and the time sequence rather strange, with maxima at the beginning and the end of the darkness period.

It is important to remember that other experiments clearly exclude any shielding of gravitation of the so-called "Majorana" type (these phenomena were first investigate by Majorana at the beginning of 1900) [57]. Besides, one would expect a possible shielding effect by the moon to have an analogue for artificial satellites, namely a shielding of solar gravity when the satellite enters the shadow of the earth. Anomalies of this type were actually reported [58], though they are very difficult to confirm, because the irregularities which affects the motion of the artificial satellites are numerous, especially when they are close to the surface of the earth.

(i) Weak gravitational shielding by superconductors

In this variegated field of investigations on possible gravitational anomalies, the work by E. Podkletnov stands out, originally appeared in 1992 [1], then in improved version in 1995 [2]. It describes possible gravitational anomalies caused by HTC superconductors. The observed anomalies reached a maximum of about 2% of g , in transient situations, and 0.3-0.5% of g in almost stationary form. These anomalies were produced by means of discs with multiple layers, rotating at high speed, in very particular conditions, which still have not been completely duplicated. A NASA team already produced a first simplified reproduction of the experiment in 1997 [3], and a new version should start giving some data this year. Besides the remarkable experimental difficulties, the results are puzzling under the theoretical point of view. In fact, the strength of the anomalies is very large with respect to what has been previously observed, and no sufficiently complete theory exists, which can explain this kind of phenomena (see Section 4.1). Here in fact both gravitation is called into play, of which a complete quantum theory does not exist, and typically quantum phenomena (behaviour of the macroscopic wave functions in superconductors). Furthermore, not conventional superconductors are involved, but HTC superconductors, for which several issues are still unsettled, like the pairing mechanism etc.

(j) Terahertz radiation emission by HTC superconductors

A new type of terahertz radiation was discovered by Japanese scientists by irradiating HTC superconductive films with femtosecond laser pulses [59, 60]. The radiation mechanism is thought to be connected with the ultrafast supercurrent modulation by the laser pulses, which induces nonequilibrium superconductivity. The principal design of the experimental installation has some common features with our gravity impulse generator and the behavior of the superconducting crystallized materials might have a similar origin.

5 Conclusions

The experimental apparatus has shown that an impulse of gravitational-like force freely propagating through different physical media can be generated by a dual layered YBCO HTSC under pulsed electric current. The impulse propagates parallel to the direction of the discharge and orthogonal to the surface of the HTSC. The intensity of the impulse has been found to increase with increasing discharge energy, and to depend on the chemical composition and structure of the HTSC and on its internal magnetic state. In a typical measurement, the mechanical energy imparted by the impulse to a pendulum of mass 18.5 g was between $4 \cdot 10^{-4} J$ and $23 \cdot 10^{-4} J$ (Table 1).

From the theoretical point of view, we understand the effect as the result of an anomalous interaction between a special class of gravitational vacuum fluctuations and the macroscopic wave function of the superconductor. This interaction is locally activated when the product of the pairs density ρ and its second derivative ρ'' is sufficiently large. The sign of ρ'' must furthermore be positive. These conditions can be satisfied in the presence of intense transport current and magnetic flux penetration.

Attempts of scientists to control gravity have been present for a long time and in the future these efforts will almost certainly become more prominent. Albert Einstein spent the

last years of his life trying to integrate gravity with the other laws of physics and the entire scientific community remains intrigued with the problem of gravity ever since. However, since our knowledge of gravity is poor in comparison to that of the other fundamental forces, we are unable to control it in any fundamental way. We are therefore left with the option of carrying out experiments based on new theories, on scientific intuition and careful analysis of previous results. This work indicates that a kind of artificial gravity can be generated using the unique properties of superconducting ceramic materials and a combination of electric and magnetic forces.

Acknowledgment - G.M. was supported in part by the California Institute for Physics and Astrophysics via grant CIPA-MG7099.

References

- [1] E. Podkletnov and R. Nieminen, *A Possibility of Gravitational Force Shielding by Bulk $YBa_2Cu_3O_{7-x}$ Superconductor*, Physica C Vol. 203 p. 441 (1992).
- [2] E. Podkletnov, *Weak Gravitational Shielding Properties of Composite Bulk $YBa_2Cu_3O_{7-x}$ Superconductor Below 70 K Under EM Field*, LANL Physics Preprint Server, preprint cond-mat/9701074, January 1997. Available on the net: <http://www.gravity.org/msu.html>.
- [3] N. Li, D. Noever, T. Robertson, R. Koczor and W. Brantley, *Static Test for a Gravitational Force Coupled to Type II YBCO Superconductors*, Physica C 281, 260-267. R. Koczor and D. Noever, *Fabrication of Large Bulk Ceramic Superconductor Disks for Gravity Modification Experiments and Performance of YBCO Disks Under e.m. Field Excitation*, NASA Marshall, Huntsville, AL, AIAA 99-2147, 35th AIAA/ASME/SAE/ASEE Joint Propulsion Conference, 20-24 June 1999, Los Angeles, CA.
- [4] Frederic N. Rounds, *Anomalous Weight Behavior in $YBa_2Cu_3O_{7-x}$ Compounds at Low Temperature*, NASA Ames Research Center. Preprint physics/9705043.
- [5] Harald Reiss, *A Possible Interaction Between Gravity and High Temperature Superconductivity-By a Materials Property*, Submitted to the 15th. European Conf. Thermophys. Properties, Wrzburg, Germany, Sept. 5-9, 1999.
- [6] Ning Li and D. Torr, *Effects of a gravitomagnetic field on pure superconductors*, Phys. Rev. D 43 (1991) 457; *Gravitational effects on the magnetic attenuation of superconductors*, Phys. Rev. B 64 (1992) 5489.
- [7] Ning Li and D. Torr, *Gravitoelectric-electric coupling via superconductivity*, Found. Phys. Lett. 6 (1993) 371.
- [8] G. Fontana, *A possibility of emission of high frequency gravitational radiation from junctions between d-wave and s-wave superconductors*, report cond-mat/9812070;

- Gravitational radiation and its application to space travel*, in CP504, Space Technology and Applications International Forum-2000, edited by M.S. El-Genk, AiP, p. 1085.
- [9] M. Agop, C. Gh. Buzea and P. Nica, *Gravitational shielding in an electromagnetic field. Local gravitoelectromagnetic effects on a superconductor*, Physica C: Superconductivity, 339 (2) (2000) pp. 120-128
 - [10] U. Balachandran, R.B. Poeppel, J.E. Emerson, S.A. Johnson, M.T. Lanagan, C.A. Youngdahl, Donglu Shi, K.C. Goretta, N.G. Eror, *Synthesis of Phase-Pure Orthorhombic $YBa_2Cu_3O_{7-x}$ under Low Oxygen Pressure*, Materials Letters 8 (1989) 454-456.
 - [11] T.B. Lindemer, F.A. Washburn, C.S. MacDougall, O.B. Cavin, *Synthesis of Y-Ba-Cu-O superconductors in subatmospheric oxygen*, Physica C 174 (1991) 135-143.
 - [12] M. Murakami, *Processing of bulk YBaCuO*, Supercond. Sci. Technol. vol. 5, pp 185-203, 1992.
 - [13] S. Nariki, N. Sakai and M. Murakami, *Fabrication of large melt-textured Gd-Ba-Cu-O superconductor with Ag addition*, Physica C: Superconductivity, 341-348 (1-4) (2000) pp. 2409-2412.
 - [14] M. Muralidhar, S. Koishikawa, M.R. Koblishka and M. Murakami, *Study of superconducting properties of OCMG processed (Nd, Eu, Gd)-Ba-Cu-O with Pr doping*, Physica C: Superconductivity, 314 (3-4) (1999) pp. 277-284.
 - [15] S.I. Yoo, N. Sakai, T. Higuchi and M. Murakami, *Melt processing for obtaining $NdBa_2Cu_3O_y$ superconductors with high T_c and large J_c* , Appl. Phys. Lett. 65 (1994) pp. 633-635.
 - [16] V.R. Todt, X.F. Zhang and D.J. Miller, *Nucleation and growth of single- and multiple-domain $YBa_2Cu_3O_{7-x}$ Levitators: Influence of Seed Crystallography*, IEEE Trans. on Appl. Super., vol. 7(2), pp. 1801-1804, June 1997.
 - [17] Chan-Joong Kim, Young A. Jee, Gye-Won Hong, Tae-Hyun Sung, Young-Hee Han, Sang-Chul Han, Sang-Joon Kim, W. Bieger, G. Fuchs, *Effects of the seed dimension on the top surface growth mode and the magnetic properties of top-seeded melt growth processed YBCO superconductors*, Physica C 331 (2000) pp. 274-284.
 - [18] G. Modanese, *Theoretical analysis of a reported weak gravitational shielding effect*, Europhys. Lett. 35 (1996) 413-418.
 - [19] G. Modanese, *Role of a "local" cosmological constant in euclidean quantum gravity*, Phys. Rev. D 54 (1996) 5002.
 - [20] G. Modanese, *Tunneling of a massless scalar field through a 3D gaussian barrier*, J. Math. Phys. 40 (1999) 3300.

- [21] G. Modanese, *Virtual dipoles and large fluctuations in quantum gravity*, Phys. Lett. B 460 (1999) 276; *Large “dipolar” fluctuations in quantum gravity*, Nucl. Phys. B 588 (2000) 419-435; *Paradox of virtual dipoles in the Einstein action*, Phys. Rev. D 62 (2000) 087502;
- [22] G. Modanese, *The dipolar zero-modes of Einstein action: An informal summary with some new issues*, in Proceedings of the Vigier III Symp. (Aug. 21-25, 2000, U. California Berkeley), Kluwer Acad. Press.
- [23] A.G. Riess et al., Astronom. J. 116 (1998) 1009; S. Perlmutter et al., Astrophys. J. 517 (1999) 565.
- [24] I.L. Shapiro and J. Solà, *On the scaling behavior of the cosmological constant and the possible existence of new forces and new light degrees of freedom*, Phys. Lett. B 475 (2000) 236; *Scaling behavior of the cosmological constant: interface between quantum field theory and cosmology*, report UAB-FT-490, hep-th/0012227.
- [25] G. Modanese, *Local contribution of a quantum condensate to the vacuum energy density*, report gr-qc/0107073.
- [26] J. Waldram, “Superconductivity of metals and cuprates”, IoP, London, 1996.
- [27] D.R. Tilley and J. Tilley, “Superfluidity and superconductivity”, IoP, Bristol, 1990.
- [28] G. Modanese, *The London field in bulk layered superconductors*, report cond-mat/9909441.
- [29] G. Modanese, *Gravitational anomalies by HTC superconductors: a 1999 theoretical status report*, report physics/9901011.
- [30] For the gravitational case: G. Modanese, *Potential energy in quantum gravity*, Nucl. Phys. B 434 (1995) 697. For the other cases: K. Symanzik, Comm. Math. Phys. 16 (1970) 48.
- [31] For a recent account and references see C. Barcelo, S. Liberati and M. Visser, *Analog gravity from field theory normal modes?*, report gr-qc/0104001.
- [32] B. Mashhoon, H. Young Paik and C. Will, *Detection of the gravitomagnetic field using an orbiting superconducting gradiometer; theoretical principles*, Phys. Rev. D 39, 2825 (1989).
- [33] I. Ciufolini and J. Wheeler, “Gravitation and Inertia”, Princeton Series in Physics, Princeton university press, 1995, Cap. 6.
- [34] R.P. Lano, *Gravitational Meissner effect*, report U.ofIowa 96-4, March 1996.
- [35] H. Hayasaka and S. Takeuchi, Phys. Rev. Lett. 63 (1989) 2701.
- [36] B. M. Barker and R. F. O’Connell, *The gravitational interaction: spin, rotation and quantum effects - A review*, Gen. Rel. Grav. 11 (1979) 149.

- [37] R. F. O’Connell, Phys. Lett. A 32 (1970) 402.
- [38] R. F. O’Connell and S. N. Rasband, Nature Phys. Sci. 232 (1971) 193.
- [39] A. Peres, Phys. Rev. D 18 (1978) 2739. See also Y. N. Obukhov, *Spin, gravity, and inertia*, report gr-qc/0012102.
- [40] R. C. Ritter, L. I. Winkler, and G. T. Gillies, *Search for anomalous spin-dependent forces with a polarized-mass torsion pendulum*, Phys. Rev. Lett. 70 (1993) 701.
- [41] H. Wallace, *Method and apparatus for generating a secondary gravitational force field*, US Patent N. 3626605 (1971).
- [42] G. A. Ummarino, *Possible alterations of the gravitational field in a superconductor*, report cond-mat/0010399.
- [43] S. M. Carroll and G. B. Field, *Consequences of propagating torsion in connection-dynamic theories of gravity*, Phys. Rev. D 50 (1994) 3867.
- [44] A. Ye. Akimov and V. Ya. Tarasenko, *Models of polarization states of the physical vacuum and torsion fields*, Izd. Vuzov. Fizika, 1992, Nov. 3, pp. 13-23. See also on the Web: <http://www.amasci.com/freenrg/tors/doc17.html>.
- [45] K. Nordtvedt, Int. J. Theor. Phys. 27 (1988) 1395.
- [46] J. F. Woodward, *Laboratory test of Mach’s principle and strong-field relativistic gravity*, Found. Phys. Lett. 9 (1996) 247, and references.
- [47] D.E. Groom et al. (Particle Data Group), *Review of particle physics*, Eur. Phys. J. C **15** (2000); <http://pdg.lbl.gov>.
- [48] G. T. Gillies, *The Newtonian gravitational constant: recent measurements and related studies*, Rep. Prog. Phys. 60 (1997) 151-225.
- [49] W. Michaelis, H. Haars, and R. Augustin, Metrologia 32, 267 (1995). M. Fitzgerald and T. R. Armstrong, IEEE Trans. on Inst. and Meas. 44, 494 (1995). H. Walesch, H. Meyer, H. Piehl, and J. Schurr, IEEE Trans. on Inst. and Meas. 44, 491 (1995). V.P. Izmailov, O.V. Karagioz, V.A. Kuznetsov, V.N. Mel’nikov, and A.E. Roslyakov, Measurement Techniques 36, 1065 (1993).
- [50] N. Arkani-Hamed, S. Dimopoulos, G. Dvali, *The Hierarchy Problem and New Dimensions at a Millimeter*, Phys.Lett. B429 (1998) 263-272.
- [51] C.D. Hoyle, U. Schmidt, B.R. Heckel, E.G. Adelberger, J.H. Gundlach, D.J. Kapner, and H.E. Swanson, *Submillimeter Tests of the Gravitational Inverse-Square Law: A Search for “Large” Extra Dimensions*, Phys. Rev. Lett. (to be published).
- [52] D. La and P. J. Steinhardt, Phys. Rev. Lett. 62 (1989) 376 for status and references on scalar-tensor gravitational theories. See also S. Calchi Novati, S. Capozziello and G. Lambiase, *Newtonian limit of induced gravity*, report astro-ph/0005104.

- [53] J.D. Anderson et al., Phys. Rev. Lett. 81 (1998) 2858; *Study of the anomalous acceleration of Pioneer 10 and 11*, report gr-qc/0104064.
- [54] J.P. Mbelek and M. Lachieze-Rey, report gr-qc/9910105.
- [55] T. Kuusela, *New measurements with a torsion pendulum during the solar eclipse*, General Relativity and Gravitation, 4, 543-550, 1992. D. C. Mishra, M. B. S. Vyaghreswara Rao, *Temporal variation in gravity field during solar eclipse on 24 October 1995*, Current Science, 72(11), 782-783, 1997. L. A. Savrov, *Experiment with paraconic pendulums during the November 3, 1994 solar eclipse in Brazil*, Measurement Techniques, 40 (6), 511-516, 1997. And references.
- [56] Qian-shen Wang et al., *Precise measurement of gravity variations during a total solar eclipse*, Phys. Rev. D 62 (2000) 041101. C.S. Unnikrishnan, A. K. Mohapatra, G.T. Gillies, *Anomalous gravity data during the 1997 total solar eclipse do not support the hypothesis of gravitational shielding*, Phys. Rev. D 63 (2001) 062002.
- [57] *New limits on the gravitational Majorana screening from the Zurich G experiment*, C.S. Unnikrishnan, G.T. Gillies, Phys. Rev. D 61 (2000) 101101
- [58] T. Van Flandern, *Possible new properties of gravity*, Astrophys. Space Sci. 244 (1996) 249, and ref.s.
- [59] M. Tonouchi, M. Tani, Z. Wang, K. Sakai, N. Wada, M. Hangyo, *Novel Terahertz Radiation from Flux-Trapped $YBa_2Cu_3O_{7-\delta}$ thin Films Excited by Femtosecond Laser Pulses*, Jpn. J. Appl. Phys. Vol. 36 (1997) pp. L93-L95.
- [60] M. Hangyo, S. Tomozawa, Y. Murakami, M. Tonouchi, M. Tani, Z. Wang, K. Sakai, S. Nakashima, *Terahertz radiation from superconducting $YBa_2Cu_3O_{7-\delta}$ thin films excited by femtosecond optical pulses*, Appl. Phys. Lett. 69 (14), (1996), pp. 2122-2124

Figure Captions

Fig.1 Initial setup of the impulse gravity generator.

Fig.2 Improved variant of the impulse gravity generator.

Fig.3 Discharge chamber of the impulse gravity generator.

Fig.4 Arkadjev-Marx high-voltage pulse generator.

Fig.5 Pendulum in a glass cylinder under vacuum. (The actual cylinder is wide enough to allow a complete oscillation.)

Fig.6 Correlation between the voltage discharge and the deflection of the pendulum.

Fig.7 Impulse recorded by the microphone at a 67 deg. impact angle. Time scale is sampling periods at $f_s = 44.1 \text{ kHz}$. There is a 50 Hz noise due to power grid. The signal is unfiltered.

Fig.8. Relative pulse impulse versus impact angle.

This figure "figure1and2.jpg" is available in "jpg" format from:

<http://arXiv.org/ps/physics/0108005v2>

This figure "figure3.jpg" is available in "jpg" format from:

<http://arXiv.org/ps/physics/0108005v2>

This figure "figure4.jpg" is available in "jpg" format from:

<http://arXiv.org/ps/physics/0108005v2>

This figure "figure5.jpg" is available in "jpg" format from:

<http://arXiv.org/ps/physics/0108005v2>

This figure "figure6.gif" is available in "gif" format from:

<http://arXiv.org/ps/physics/0108005v2>

This figure "figure7.gif" is available in "gif" format from:

<http://arXiv.org/ps/physics/0108005v2>

This figure "figure8.gif" is available in "gif" format from:

<http://arXiv.org/ps/physics/0108005v2>

Physical Phenomena Observed during Strong Electric Discharges into Layered Y123 Superconducting Devices at 77 K

Claude Poher (Corresponding author) & Danielle Poher

Laboratoire Aurora - 33 Chemin de la Bourdette, F31400, Toulouse, France

Tel: 33-562-177-896 E-mail: claudio.poher@wanadoo.fr

Received: May 4, 2011 Accepted: May 18, 2011 Published: November 1, 2011

doi:10.5539/apr.v3n2p51

URL: <http://dx.doi.org/10.5539/apr.v3n2p51>

Abstract

Electric discharges of several megawatts were applied, at 77 K, to propelling devices made of Y123 superconducting layers and thin insulating layers. During the discharges, the devices were strongly pushed in the direction opposed to the electron flow. The layered devices were apparently propelled by their emission of a momentum-bearing flux of an unknown nature. This flux weakly accelerated distant irradiated matter and created several physical effects not yet reported. The emitted beam had no electric charge, and traveled through materials without apparent absorption or dispersion, at a speed much greater than 1% the speed of light. The kinetic energy transferred by the propelling momentum of the devices to external masses, were proportional to the square of the electric energy of the discharges. No known effects were found which could explain these phenomena.

Keywords: Electric propulsion, Superconductors applications, Inertia, Gravitation, Dark matter, Dark energy, Energy generation

1. Introduction

The motivation for the present work originated from the experimental testing of an electric space propelling system we invented and patented (C. Poher, 1992; C. Poher, 2006). This device, called “emitter” uses thick layers of Y123 superconducting material and thin layers of insulating material that is a derivative of the Y123 material.

The propelling phenomenon we observed during these experiments seems to be tied with the inertia phenomenon acting upon very strongly accelerated electrons inside the device. However, the propelling emitter shows simultaneously an energetic behavior and diverse distant physical effects implying an interaction with an external source of energy. In order to satisfy energy conservation, we had effectively to suspect an interaction of the accelerated electrons with a field of an unknown nature surrounding the experimental apparatus.

In experiments reported here, a static superconducting material was used with internal free electrons strongly accelerated during electric discharges of short duration. Distant acceleration of irradiated matter and propulsion of the emitting material were observed. The second effect, the most conspicuous, has not been reported before.

2. Experimental setup and methods

2.1 Principle of the experiments

The experiments (Figs. 1 and 2) consisted in the application of high-voltage electric discharges (megawatts) of direct current lower than the critical current, generated from a bank of charged capacitors, into a patented (C. Poher, 2006) device made of superconducting material bathing in liquid nitrogen. The time course of the discharge current was related to the charge voltage of the energy storage capacitor C and to the values of the real elements of the circuit (Fig. 2). We chose and measured: $C = 46.86 \mu\text{F}$, $R_c = 0.081 \Omega$, $R_s = 0.130 \Omega$, $L_c = 0.80 \mu\text{H}$. Our device, called “emitter” EM (see below) had a fixed internal resistance of the order of 0.01 to 0.05 Ω that is proper to each emitter.

We observed physical effects of the discharge directed both upward, on the emitter support, and downward, away from the emitter, along the vertical axis Φ of the discharge current, with several detectors located far from the emitter (Fig. 3). Sets of measurements were made for different discharge voltages, with different

emitters or with different kinds of metallic conductors replacing the emitter, inside liquid nitrogen or in the air. Experiments of the same type were done during the cooling down and during the warming up of the emitter, when the state of the S1 and S2 layers changed from conductive to superconductive and vice versa. We also observed discharges in other kinds of materials, such as piezoelectric and ferroelectric devices.

2.2 Emitter

The assigned role of the patented emitter was to accelerate strongly ($>10^{15}$ m/s²) numerous electrons ($>10^{21}$) in the vertical up $\rightarrow$ down direction, during short ($\approx 3 \cdot 10^{-5}$ s) electric discharges, without distorting simultaneously, in the opposed direction, the lattice atoms of the material as this is the case inside resistive materials.

Emitters were made of two high temperature superconductive material thick films (30 μ m) S1 and S2 of the same chemical composition (Fig. 1) deposited on metallic electrodes. The useful acceleration of electrons occurred mainly inside the grains of S1 and S2 that were situated very close to insulated thin films (< 1 μ m), made of a non conducting material existing between layers S1 and S2 and the metallic electrodes e+ and e-. Electric field was effectively the largest inside the insulated layers but did not stop abruptly at their frontiers. There was also an accelerating electric field between some grains of S1 and S2 where the electric contacts were not perfect.

Layers S1 and S2 had a larger superconducting critical temperature (≈ 90 K) than the boiling temperature of liquid nitrogen (77K). The sintered material of layers S1 and S2 was a classical cuprate $\text{YBa}_2\text{Cu}_3\text{O}_{7-x}$ which method of fabrication has been described by many authors (M. K. Wu, 1987; B. Raveau, 1988; M. Murakami, 1992; U. Naoki, 1992). The insulated interface thin films were made of $\text{YBa}_2\text{Cu}_3\text{O}_5$ material formed by local loss of oxygen atoms during the sintering process, this creating also conducting surface oxide on the metallic electrodes.

Our method of fabrication was classical: micron size grinded powders of Y_2O_3 , BaCO_3 , CuO were mixed and heated up during 24 hours at 830 °C under partial vacuum (2 to 30 hPa) and oxygen flow (120 μ g/s). The S1 and S2 layers were sintered at 900 °C, under the same partial vacuum. We made and tested more than one hundred such bi-layered emitters with an area of 9 to 50 cm². These displayed a propelling performance proportional to the film area.

2.3 Emitter support

The emitter was bolted between two flat electrodes at the tip of a metallic support (Fig. 3). This support offered a low electrical resistance to the intense discharge current, and transmitted the momentum from the emitter to an insulated rod pushing the mobile magnets of a linear alternator. The emitter support was made of two bolted flat elastic L-shaped stainless steel bars, with a horizontal part forming a parallelogram attached to the setup, and a vertical part maintaining the emitter axis in position while permitting a slight vertical movement of a few mm only. Metallic bars had a 40 ± 2 mm² section. Because of this mechanical configuration, the emitter, its electrodes, and their support could not move independently.

2.4 Discharge system

The 46.86 ± 0.01 μ F energy storage capacitor C (Fig. 1 and 2) was made of ten polypropylene $4.7 \mu\text{F} \pm 5\%$ capacitors, insulated to 7500 V, and connected in parallel. It could be charged up to 4000 V by an external DC power supply. Discharges of up to 10,000 A were done through a large thyristor, insulated to 4500 V, and capable to withstand a 13,000 A surge current.

2.5 Emitter momentum sensor, the linear alternator

The momentum from the emitter was carried up by the metallic support and transferred by contact to an insulated rod suspended by flat springs. The rod transferred itself the momentum to the moving magnets of the linear alternator, magnets also suspended by flat springs. The stator of that alternator was bolted to a separate support (Fig. 3). The momentum transfer stopped the movement of the emitter support. So this one remained macroscopically almost at rest. In order to obtain an efficient momentum transfer, the total moving masses of the rod and of the mobile magnets were chosen equal to the total moving masses of the emitter plus its support.

During a discharge, the alternator windings delivered a voltage proportional to the velocity of its mobile magnets, so the alternator output peak voltage was proportional to the transmitted momentum. An electronic circuit with a digital voltmeter measured this peak voltage. We calibrated this momentum sensor experimentally (9.71 ± 2 % g.m/s per peak Volt without connected charge).

2.6 Detectors in the double Faraday's cage

Distant detectors were shielded from electromagnetic fields by a double Faraday's cage made of two 0.8mm-thick aluminum enclosures. This cage was well insulated from the vibrations of the emitter system by independent supports. Inside the one meter height cage, eight drawers were put up for detectors. The bottom of the upper drawer was 26 ± 0.5 cm under the emitter level. Four kinds of detectors performed measurements far from the emitter, along its vertical axis Φ (Fig. 3). (i) Several accelerometers with piezoelectric and inductive sensors, delivering voltages proportional to the acceleration or to the speed of tiny non-ferromagnetic masses placed along the axis Φ . (ii) Flat capacitors with electrodes perpendicular to Φ . (iii) Electric conductors aligned with Φ . These three kinds of sensors were compensated for the residual electromagnetic field existing inside the Faraday's cage during discharges. (iv) A flat tank of water the surface waves of which were recorded by light reflection at grazing incidence by a video camera. For the sake of brevity the measurements from all these detectors will not be described, except those from the piezoelectric accelerometer, as it helped showing the existence of an emitted propelling flux and measuring one of its characteristics.

2.6.1 Piezoelectric sensor accelerometer

We used an industrial stack of several hundred piezoelectric elements made of PZT material, and connected in parallel. This sensor was an actuator P888-91 from PI, a German industry. The proper mass of the piezoelectric elements acted as an accelerometer mass, pushed by the emitted flux from the emitter. This stack was placed vertically along the axis of the emitter. This detector could be moved around, in order to determine the intensity distribution of the propelling flux along the propagation axis or at some distance from it (29 to 95 cm away). This piezoelectric sensor was able to measure a force less than $30 \mu\text{s}$ in duration and more than 0.02 mN in intensity. The detector was calibrated by the impact of a tiny body of known mass falling from several known heights. By adding known masses of different not ferromagnetic materials on top of the stack we were able to adjust the sensitivity of this accelerometer, and check that the force was proportional to the total irradiated mass, as this should be the case for an acceleration.

2.7 Data recording

Mechanical phenomena evolving slowly were recorded by a distant video camera at rate 25 ± 0.01 frames/s, and electric phenomena evolving rapidly were recorded by a digital memory oscilloscope (256 levels or $\pm 0.4\%$ of full scale), enclosed in an independent double Faraday's cage, and triggered through an optoelectronic circuit.

The time window of the oscilloscope was chosen short enough (from -30 to $+70 \mu\text{s}$) for the aerial sounds and mechanical vibrations, caused by the discharge, to travel less than 2 cm during this time, and so to avoid their recording by the sensitive sensors inside the Faraday's cage.

2.8 Taking care of the electromagnetic effects on the Faraday's cage sensors

The intense and brief discharge current into the emitter created a strong electromagnetic field, not completely eliminated by the double Faraday's cage. A voltage was induced in some of the sensors by the residual electromagnetic field, and this had to be taken into account in order to detect the signal induced by the phenomenon under study. As shown below, the voltage induced in the detectors by the electromagnetic field was proportional to the discharge voltage, while the signal induced by the phenomenon under study was proportional to the square of the discharge voltage. So they could be discriminated by varying the discharge voltage as follows. First, the detectors output signals were recorded during several discharges into a layered emitter bathing in liquid nitrogen. Next, they were recorded with the same current discharged into a stack of copper plates (control) replacing the layered emitter, and creating only the same electromagnetic field.

2.9 Experimental protocol

Physical phenomena occurring during the discharges being quite brief, the displays of the digital instruments, the movement of the momentum transfer rod and the screen of the memory oscilloscope were recorded by a digital video camera for subsequent analysis on a computer. The following protocol was systematically used:

- (1) The tested emitter was bolted on its support and the support bolted on the experimental setup. The cryostat was filled with liquid nitrogen and the liquid level completed from time to time to compensate for evaporation. Forty minutes without any action were needed to reach thermal equilibrium. Then the video camera was started for permanent recording of the instruments during phases 2-4.
- (2) The storage energy capacitor C was charged up to 600 V by the external power supply. The digital memory oscilloscope was put in waiting mode, to be triggered by the thyristor command circuit. The automatic command circuit of the thyristor was started. Experimenters went away for safety, and for preventing induced vibrations.

Within 10 seconds, vibrations of the experimental system were damped and ceased completely. At the end of a 10-s waiting period, the thyristor and the oscilloscope were automatically triggered. After the discharge a recording of the oscilloscope screen image was manually made on an USB memory chip for ulterior recovery and use.

(3) All steps in sequence (2) were repeated with a 200 V increase of the charge voltage of C.

(4) After a charge voltage of 3600 V was reached, the experiment was repeated once again starting at 600 V.

3. Experimental results

More than 3500 discharges were recorded and analyzed from April 2007 to March 2011, with 130 different emitters. For examples, see the video movie in reference (C. Poher & D. Poher 2010 a) and Fig 4.

3.1 Experimental conditions

Typical emitter voltage and current waveforms during a discharge (Fig. 5) show that the emitter was only resistive, and the total duration of the discharge ($30 \pm 5 \mu\text{s}$) was almost the same for each emitter. The time course of the instantaneous electric power applied to this emitter (Fig. 6) shows that the total energy transferred to the emitter was 3 to 4% of the stored energy. The peak current was equal to the charge voltage divided by 0.44 ohms.

The time width of the discharges, at half the peak power, was $12 \pm 5 \mu\text{s}$, and 90% of the stored electric energy was discharged from 6 to 22 μs after the onset of the discharge. The peak power of discharges was generally observed $10 \pm 2 \mu\text{s}$ after their onset. The similarity of the discharge parameters resulted from the internal resistance ($R_c + R_s$) of the discharge circuit, which was much larger than the emitter resistance R_{em} , and imposed by the non oscillating current constraint $[(R_c + R_s + R_{em}) \geq 2 (L_c / C)^{1/2}]$.

Four percent of the energy stored into the capacitor bank was dissipated in the emitter as heat. Most of the stored energy (95%) was dissipated as heat by the other components of the discharge circuit, including the amortization resistor of 0.13 Ω . A small part of the stored energy ($< 1\%$) was radiated as electromagnetic field.

3.2 Effects observed during discharges

3.2.1 Propulsive momentum

The main physical effect observed was an upward propulsive momentum of the emitter, in the opposite direction to the flow of electrons. During all discharges in the layered emitter larger than 800 V, the mobile magnets of the linear alternator always jumped up. For example, during a 2863 ± 1 V discharge in emitter EM8, the propulsive momentum was $125 \pm 5 \text{ gm/s}$. In this example, the discharge duration being 16 μs , the corresponding average propulsive force was $7800 \pm 375 \text{ N}$, and the average acceleration of the emitter support was $15,600 \pm 750 \text{ m/s}^2$.

Fig. 7 shows that, for a typical emitter, the momentum P created into the emitter, and transferred to the mobile magnets of the linear alternator, was proportional to the electric energy of the discharge. Experimentally, for emitter EM2, $P = 1.12 \times 10^{-8} U^2$ where U is the charge voltage, the factor 1.12×10^{-8} being expressed in $\text{kg.m.s}^{-1}.\text{V}^{-2}$. The electric energy E_e of the discharge is $E_e = CU^2/2$. So, with the storage capacitor $C = 46.86 \mu\text{F}$, $P = 4.78 \times 10^{-4} E_e$, the factor 4.78×10^{-4} being expressed in $\text{m}^{-1}.\text{s}$.

Similar results were obtained with all emitters, showing that the propelling momentum was proportional to the product of the number of accelerated electrons by their acceleration inside the emitter. The variability between performances of different emitters appeared to be proportional to the films area.

When the emitter was turned upside down (reversed current direction) the momentum did not change and its direction remained opposite to the electrons flow.

3.2.2 Effect on the distant accelerometer

During discharges, several lower amplitude physical effects were observed inside the double Faraday's cage at a distance from the emitter, along the Φ axis of the discharge current, especially with the accelerometer. A typical example of the output signal amplitude of the piezoelectric accelerometer as a function of the discharge energy is shown in Fig. 8. This accelerometer was negligibly affected by the residual electromagnetic field. During discharges applied to a stack of copper plates (false emitter) creating the same electromagnetic field, it showed no output signal, only electronic noise. During experiments of Fig. 8, at a discharge voltage of 2900 ± 1 V, the sensitive mass of the piezoelectric accelerometer was accelerated to $0.125 \pm 10\% \text{ m/s}^2$. This corresponds to a transferred momentum of $8.8 \times 10^{-8} \text{ kg.m/s}$ ($\pm 10\%$). From the tests described in subsection 2-6, the force acting on the piezoelectric sensor was found to be proportional to the mass irradiated by the propelling flux (this is an acceleration) and to be independent of the nature of the irradiated mass of the accelerometer.

3.2.3 Other physical effects

Three other physical effects were simultaneously observed during discharges into the emitters: emission of sound, emission of light and pushing of free electrons inside Faraday's cage sensors.

3.2.3.1 Sound

During all discharges larger than 500 V, a particular loud sound was heard and recorded. This was a short (< 300 ms) and powerful whiplash-like sound, with an abrupt start (< 25 μ s). It was recorded by the video camera at 44 kHz sampling rate (listen to it in video of reference (C. Poher & D. Poher 2010 ar). No definite source was found for this sound apparently emitted by the whole experimental apparatus. Its intensity was correlated with the observed propulsive momentum. No such sound was heard or recorded during discharges applied to dummy emitters or devices other than the tested layered emitters.

3.2.3.2 Light

During all discharges larger than 1000 V, a brief flash of light coming from inside the cryostat was noticed. This flash was recorded by the video camera, at least when the electronic shutter of its CCD sensor was not closed at the discharge instant. It was only visible on a single video image per discharge with unknown automatic individual exposure duration of less than 40 ms. The light flash was too brief for obtaining an exploitable spectrum with our equipment. A rough RGB photometry of the emitted light was obtained from the color video image. The photometry ratios suggest, by comparison with nitrogen spectroscopic tables, a compatibility with nitrogen emission lines in visible light. The agitation of the boiling surface of liquid nitrogen did not allow exploitable pictures of the light source. The best we have been able to do was to use the shadows projected by the light on the front face of the instruments, to determine an approximate size and position of the light source inside the cryostat. Shadows geometry suggests the light source volume was small (< 5 cm³), and located between the lower end of the emitter support and the bottom of the cryostat. No light was observed during discharges into a dummy emitter made of a stack of copper plates or devices other than the tested layered emitters. No light was observed during discharges in our layered emitters in the absence of emitter momentum, for example during the emitter cooling down.

3.2.3.3 Pushing of electrons and of water molecules

Appropriate detectors placed inside the Faraday's cage, such as a triple capacitor and a double solenoid, showed that the propelling flux pushed electrons inside dielectrics and conductors, and that it was not made of charged particles. The propelling flux created tiny waves on the surface of irradiated water. These effects will not be discussed here.

3.3 These physical effects are specific to the tested layered emitters

Three hundred discharges have been recorded in other materials than the tested layered emitters : (i) In normal conductors made of aluminum, brass or copper, both at room temperature and in liquid nitrogen (see the video movie (C. Poher & D. Poher 2010 a) for a discharge applied to a stack of copper plates). (ii) In emitters of the same type of material, but of a different chemical composition. (iii) In fully superconductive emitters with no layers. (iv) In emitters where the materials composing the layers were mixed together before the final thermal treatment. (v) In piezoelectric and ferroelectric materials such as BaSrTiO₃, PZT, and PLZT, at room temperature, with a $300 \pm 10\%$ Ω resistance in parallel, allowing the discharge, as these materials are dielectrics. During discharges in all those materials, none of the effects described previously were observed.

These physical effects disappeared when the emitter layers were not superconducting. Discharges were applied to layered emitters at variable temperature. While the emitter was cooling down or warming up, respectively when liquid nitrogen was poured into the cryostat, and when it had evaporated, the progressive appearance and disappearance of the effects described previously was recorded. The full evolution took about 5 to 10 minutes. For stable effects, the emitter had to be at thermal equilibrium, at a temperature lower than the critical superconducting temperatures of the two layers. The present results were obtained with stable thermal equilibrium of the emitters during all discharges. This is the reason why 40 minutes waiting time were allowed in the experimental protocol.

3.4 Properties of the emitted flux

Properties of the flux were determined from the detectors located inside the Faraday's cage.

3.4.1 The radiance diagram of the emitter

It was determined with the piezoelectric accelerometer. This sensor measured the variation of the acceleration of irradiated matter, during constant discharge voltage (2500 ± 1 V), at a variable horizontal distance from the

vertical axis Φ of the emitter, along several azimuths. The area of the sensor was smaller than the one of the emitter. Its output voltages, at constant distance from the emitter (490 ± 1 mm) and variable lateral distances from Φ (up to 60 ± 1 mm), gave a rough radiance diagram. Repeating these measurements at different azimuths (0 to 360° by $30 \pm 3^\circ$ steps), we observed that the radiance diagram was symmetrical around Φ . The output voltage of the accelerometer was almost constant ($\pm 5\%$) in a circular area about the size of the emitter vertical projection, the acceleration diminishing away from the axis. An attenuation of 10% was recorded at $2^\circ \pm 0.2^\circ$ from Φ , 20% at $4.9^\circ \pm 0.2^\circ$, 50% at $5.8^\circ \pm 0.2^\circ$, and 67% at $7^\circ \pm 0.2^\circ$. The radiance diagram had a $11.6 \pm 0.4^\circ$ summit angle for a 6 dB attenuation. The propelling flux propagation was anisotropic, with an axis and a direction extending from the electron flow axis into the emitter.

3.4.2 The minimum propagation speed of the flux

It was determined from the output signals of two detectors, insensitive to the residual electromagnetic field of the discharge, placed inside the double Faraday's cage as far apart as possible, their vertical distance being 95 ± 0.1 cm along Φ . They were recorded simultaneously at a scale of 10 ± 0.01 μ s per division on the horizontal axis. Figure 9 shows an example of such an experiment repeated many times with different detectors. These measurements showed no time difference, up to ± 0.3 μ s, between the onsets of the voltage variations on both detectors. With a propagation of 0.95 ± 0.001 m in less than 0.3 ± 0.01 μ s, the speed of the flux was greater than $3.17(\pm 0.01) \times 10^6$ m/s, i.e. larger than 1% of c .

3.4.3 No absorption of the propelling flux by inserted matter was found

We used sets of two successive discharges in the same emitter, at the same voltage (2500 ± 1 V), while recording the output signal of the piezoelectric accelerometer and of other detectors in the Faraday's cage. Before the second twin discharge, various thick pieces of matter: steel, wood, stone, paraffin wax, granite, aluminum, water, brass etc, were inserted above the accelerometer and other detectors, in the upper drawer position. No difference in the recorded output signals, with and without insertion of matter, was found up to the accuracy of our measurements ($\pm 0.4\%$).

3.5 Kinetic energy transferred to the linear alternator and energetic efficiency

With more than sixty small area layered emitters (about 1 cm²), we observed the following average momentum P versus the discharge voltage U :

$$P = 1.12 \cdot 10^{-8} U^2 \quad (1-1)$$

However, with fifty 25 -cm² thin-films emitters such as 77YC25, we observed, on average :

$$P = 2.4 \cdot 10^{-7} U^2 \quad (1-2)$$

Consider now expression (1-1) and a free mass m lifted up to a height h by the momentum P , as in the case of the linear alternator in the present experiments. The mass initial vertical speed V is $V = P/m$. The height h attained by the mass in the earth gravitational field of acceleration g , when using the plain emitters obeying expression (1-1), is:

$$h = V^2 / 2g = P^2 / 2gm^2 = 1.25 \cdot 10^{-16} U^4 / 2gm^2 \quad (2)$$

The kinetic energy E_m transferred to mass m is therefore:

$$E_m = mV^2 / 2 = mg h = 6.27 \cdot 10^{-17} U^4 / m \quad (3)$$

The kinetic energy displayed by the linear alternator resulting from the propelling effect in the emitter, was therefore proportional to the square of the electric energy of the discharge. Indeed, the electric energy E_e stored into the discharge capacitor C is proportional to U^2 :

$$E_e = U^2 C / 2 \quad (4)$$

Therefore, the energetic efficiency of the whole experiment $\eta = E_m/E_e$ was:

$$\eta = 1.25 \cdot 10^{-16} U^2 / mC \quad (5)$$

The factor $1.25 \cdot 10^{-16}$ appearing in (5) is not a dimensionless constant. It is the square of the experimentally determined factor appearing in (1-1). With a small mC value, and by increasing the discharge voltage U it appears possible to get a positive energy balance between the kinetic energy of the lifted mass m and the discharge electric energy, under the condition that the critical current density into the emitter is not attained. The $\geq 100\%$ energy efficiency condition should be given by :

$$U \geq 8.93 \cdot 10^{-7} (mC)^{1/2} \quad (6)$$

Now consider the same calculation made from experimental result (1-2) with a larger area emitter. Expression (6) becomes now, for a larger than 100 % energy efficiency:

$$U \geq 4.17 \cdot 10^{-6} (m C)^{1/2} \quad (7)$$

3.5.1 Verification of the relationship between the experimental energetic efficiency and the discharge voltage with the linear alternator.

Experimental results (3) and (5), apparently violating energy conservation, we first suspected that the measurement of the momentum with a horizontal pendulum we first used was incorrect (See video C. Poher & D. Poher 2010 a). So we checked the form of expression (3) by replacing the horizontal pendulum by the linear alternator rated to 100 W. First, we made sure that it delivered an output voltage proportional to the velocity of its mobile magnets, and found that this was obtained with an energy efficiency of 92%. This type of alternator was also found to exhibit an excellent linearity when measuring a pulsed momentum ($\pm 0.1\%$).

The linear alternator was a Qdrive 1S102M model, rated to 100 watts. It had mobile magnets with a mass m of 432 ± 1 g. When briefly pushed by the emitter support, the mobile magnets suspended by flat steel springs, freely oscillated up and down. So the stator coil delivered an alternating voltage which peak amplitude was proportional to the vertical speed of the magnets. After a momentum transfer from the emitter support, this alternator delivered an amortized AC voltage, at about 50 Hz, during almost half a second. The peak voltage of the first oscillation was proportional to the transferred momentum. Its calibration factor determined experimentally was $9.71 \pm 2\%$ g.m/s per peak volt. Measured with this alternator, discharges into a bi-layered emitter yielded a mechanical kinetic energy proportional to the square of the electric energy stored into the capacitor C (see Fig. 10 as an example). That confirmed again the form of expression (3).

We could not check expressions (6) or (7) with the linear alternator and discharges into layered emitters because, with $m = 0.432$ kg and $C = 46.86$ μ F, the energy efficiency would exceed 100% for $U > 400$ kV and $U > 18.7$ kV respectively. These voltages cannot be attained with our present experimental system, which is limited to 4 kV discharges. This is the reason why we are planning for the future to use a specially built linear alternator with $m = 40$ grams.

3.5.2 Verification of the relationship between the experimental energetic efficiency and the discharge voltage with a slightly imbalanced horizontal pendulum.

Before using the linear alternator we measured the propelling momentum with a large moment of inertia horizontal pendulum slightly unbalanced by a small tip mass m after careful adjustment of the pendulum static balance. At rest, this tip remained in contact with the insulated top of the vertical emitter support, in order to receive the created momentum.

The diamond shape horizontal pendulum (see movie (C. Poher & D. Poher 2010 a)) had a total mass of 794 ± 1 g and a length of 588 ± 0.5 mm. It was made of an aluminum alloy and had lead masses ($M = 320$ g) at its two arms extremities. One tip received the supplementary mass ($m = 1.498 \pm 0.002$ g).

During a discharge, the pendulum larger mass end jumped up to a height h proportional to the square of the total momentum transferred to it. The maximum height h attained, and the corresponding momentum and potential energy, were determined from video images and calibrations. The horizontal pendulum had a large moment of inertia, so it rotated slowly enough to have its movement recorded accurately by the video camera at 25 images/s. Because of its flat shape and low velocity, its aerodynamic drag was minimal.

The pendulum had a potential energy calibration factor of 14.4 ± 1 μ J per mm of jump height h . It reached vertical position at 3.9 ± 0.1 mJ. The calibrated momentum versus jump height was 7.3 ± 0.2 g.m/s per $\text{mm}^{1/2}$. Its moment of inertia was $2.90 \cdot 10^{-2} \pm 0.01 \times 10^{-2}$ $\text{m}^2 \cdot \text{kg}$. The largest value of the momentum directly measurable from the height h of the pendulum, corresponding to a full rotation of the pendulum, was 125 g.m/s. However, measurement of its initial angular velocity was possible with the video camera by comparing successive images, and its kinetic energy could then be deduced knowing its moment of inertia.

We first used this pendulum method to try checking expression (7). This expression shows that, with the values of m of the horizontal pendulum and the same value of C as before, the energy efficiency should exceed 100% for $U > 1100$ V, which could apparently be checked with our present experimental system. Experiments with thin films emitters and the horizontal pendulum, up to $U > 1100$ V, yielded effectively an increasing energy efficiency, confirming expression (5), and a value of the pendulum kinetic energy approaching progressively the input electric energy. We went very close to expression (7) limit and very close to the 100 % energy efficiency with a sufficient accuracy to show that this series of expressions reflect a true behavior.

However, during these verification experiments with the horizontal pendulum, we could not measure accurately enough the kinetic energy with discharge voltages over 1000 V because the rotating movement of the pendulum became so violent that the pendulum end left the emitter support *before* full transfer of the emitter momentum.

Consequently, the emitter and its support began to jump up macroscopically, ejecting some of the liquid nitrogen out of the cryostat and condensing the surrounding atmospheric water vapor as fog, masking partially the pendulum movement to the camera. Even the heavy (1.5 kg) cryostat itself jumped up, because of the residual movement of the emitter support inside liquid nitrogen. Video (C. Poher & D. Poher 2010 a) shows the same violent effects.

Increasing further the input electric energy being potentially dangerous and quite difficult to interpret, the discharge voltage was limited to ~ 1150 V with the horizontal pendulum only method.

The experimental system should have to be considerably modified to continue this kind of verification, with a sufficiently low mass detector, able to accept the huge momentum created by the emitter.

The actual moving magnets linear alternator and the horizontal pendulum methods have shown here their own limits. We are now imagining the measuring means able to capture the huge created momentum and to attain the required level of accuracy.

Nevertheless we consider that this is only a technical question that will be solved in the future. So, the series of relations (1-1) to (7) have been experimentally confirmed by so many results that we should consider them to be a correct representation of the involved phenomena, with a quasi certainty.

4. Discussion

4.1 Comments about the observed physical effects

When powerful electric currents were discharged at 77K in superconducting emitters, four physical effects were observed: propulsive momentum, distant acceleration of matter, emitted sound and emitted light inside the cryostat. They can be tentatively interpreted as resulting from the emission by the emitters of a propelling flux propagating at high speed. Flux apparently not absorbed by intercalated materials.

4.1.1 Propulsive effect

Due to the mechanical configuration of the setup, only a vertical movement of the whole emitter, pushing up its metallic support, could cause this effect. The propulsive momentum was produced by the discharge current inside the layered emitter, because it was not observed when replacing the emitter by other materials. And also because the propelling momentum amplitude increased with the discharge current, disappeared with it. The propulsive momentum remained the same when the emitter was turned upside down, its direction being always opposed to the direction of the electron flow. This momentum, created without ejection of matter, suggests the emission by the emitter of a downward invisible flux bearing this momentum. This "propelling flux" should be detected along its propagation path, towards the nadir, under the emitter.

4.1.2 Distant acceleration of matter

The propelling flux momentum was proportional to the energy of the discharge, (Fig. 7). So if this flux was able to transfer a part of its momentum to matter inserted along its path, the transferred momentum should also be proportional to the energy of the discharge and this was actually observed (Fig. 8). Because of momentum conservation, the flux was expected to bear the whole momentum of the emitter. However, the flux transferred only a small part ($\approx 10^{-6}$ per gram of irradiated matter) of its own momentum to the piezoelectric accelerometer mass. This fact was not caused by absorption of the propelling flux by the Faraday's cage, as shown in section 3.4. This indicates a very weak interaction cross section of the propelling flux with irradiated matter. Our results show that the propelling flux weakly accelerated matter, as the force was proportional to the mass of the irradiated matter. The flux pushed matter inserted along its propagation path. Several authors (E. Podkletnov, R. Nieminen, 1992; E. Podkletnov, G. Modanese, 2003; M. Tajmar, C. J. de Matos, 2003 & 2005; M. Tajmar M., F. Plecescu, K. Marhold, C. J. de Matos, 2006) observed also fortuitously this distant phenomenon with the same properties.

4.1.3 Sound emission

A low time resolution oscillogram of that sound revealed an abrupt front ($< 20 \mu\text{s}$) suggesting a supersonic shock wave. This sound wave might have been emitted by the whole experimental apparatus, located under the emitter level, when irradiated by the propelling flux. This could explain why no definite source of this sound was found.

4.1.4 Light emission inside the cryostat

The voltage applied to the emitter was only a fraction of the discharge voltage. During 2200 ± 1 V discharges, only $\sim 400 \pm 40$ V were applied across the emitter. This was not sufficient to ionize liquid nitrogen. The emission of light inside the cryostat could result from the excitation of nitrogen atoms by the electromagnetic radiation emitted by the accelerated electrons (Bremsstrahlung effect). However it is unlikely that this low energy radiation (< 3 keV) could have traveled through the dense emitter material and the electrodes before reaching nitrogen atoms. So this light emission resulted more likely from the propelling flux itself, since it was not absorbed by the inserted matter. The ionization would result from the pushing action of the flux on electrons of nitrogen atoms. No light emission was observed in the air but the atomic density is about 700 times larger in liquid nitrogen than in the atmosphere. The fact that no flash of light was observed during emitter cooling down, while there was not yet any emitter momentum, supports the hypothesis of an effect caused by the propelling flux. For this hypothesis to be correct, the interaction of the propelling flux with nitrogen atoms should transfer a kinetic energy to the electrons of the ionized nitrogen atoms greater than several electrons-volts.

4.1.5 Minimum propagation speed of the propelling flux

The twin-signal experiments showed that the propelling flux propagates at a velocity greater than 1% of c . Many repetitions of this experiment with different pairs of detectors confirmed this minimum propagation speed. If the propelling flux would propagate at the speed of light, the time difference between two events inside the Faraday's cage would be ~ 3.3 nanoseconds, a time interval too short to be measurable with our detectors and oscilloscope.

4.1.6 Absence of absorption by inserted matter

No noticeable absorption of the propelling flux by matter was found with any of the different samples we tested. The thickness, mass and density of the inserted matter had no observable effect, up to the $\pm 0.4\%$ accuracy of our measurements. However, the propelling flux interacted weakly with the inserted matter, as shown by the piezoelectric accelerometer signal, and by the surface waves shown with the water tank. We should remark that gravitation is the only known interaction which is insensitive to the insertion of matter along its path and which interacts weakly with matter.

4.2 Analysis of possible artefacts

4.2.1 Artefacts concerning the propelling momentum of the emitter

Six possible artefactual sources for the emitter momentum were examined:

4.2.1.1 Piezoelectric effect

A reverse piezoelectric effect creates a tiny movement of the opposed sides of a piezoelectric crystal to which a voltage is applied. However, if a piezoelectric force would be present, the relationship between momentum and applied voltage would be linear and not quadratic as observed (Fig. 7). Moreover, a piezoelectric material should be a dielectric, whereas the tested emitters were conductive, almost short circuits (their resistance was lower than 0.05 ohms).

4.2.1.2 Electromagnetic effect

An electromagnetic field creates strong forces on currents in conductors and on ferromagnetic materials such as iron. However, electromagnetic forces are proportional to the current generating the field, not to the square of the current; no ferromagnetic materials were used; and no propulsive effect was observed when the emitter was replaced by a metallic conductor, of the same dimensions, submitted to the same current discharges.

4.2.1.3 Interaction with the Earth magnetic field

The interaction between the discharge current and the Earth magnetic field can create a force. However, the metallic bars configuration would create a small torque, instead of a propelling force greater than 80,000 N (largest peak force observed). Again, the force should be proportional to the current intensity, not to its square.

4.2.1.4 Thermal effect

A strong thermal effect inside liquid nitrogen could create an intense evaporation, and the nitrogen vapor could push the emitter support out of the cryostat. However, the discharge duration being extremely short (30 μ s), the vapor could not move sufficiently up to create the observed effect in synchrony with the discharge current. Moreover, the electric energy transferred to the emitter is small, only a few % of the stored energy (< 100 J). So, the amount of liquid nitrogen that would change phase with the available thermal energy (less than 3 J) would be insufficient to account for the observed effects, as liquid nitrogen needs 160 J/cm³ for evaporation. Note also that

during intense discharges, the heavy (1.5 kg) cryostat jumped up, which is unlikely from a thermal effect. Finally, if a thermal effect would be the cause of the propelling momentum, this momentum should be proportional to the square root of the discharge energy, this is not what is observed (Fig 7).

4.2.1.5 Solid-state physics effects inside the emitter material

Control experiments done with fully superconducting emitters of the same composition (but with no layers) did not show the effects found with our specific layered emitters. No effects were observed with discharges applied to emitters made of only a conductive layer type of material. Effects internal to the emitter cannot account for the acceleration of distant matter inside the Faraday's cage.

4.2.1.6 Effect resulting from the electric field applied to liquid nitrogen

When the coolant was poured into the cryostat, the propelling effect appeared after at least 10 minutes and then increased progressively, during each discharge, until the emitter temperature became uniform on the whole area of the layers. The full evolution required about 30 minutes. When liquid nitrogen had evaporated, the propelling effect diminished also progressively during 10 to 15 minutes while the temperature inside the emitter was rising above the critical superconducting temperature. The thermal inertia of the emitter, its electrodes and its stainless steel support was clearly involved.

4.2.2 Artefacts about the propelling flux effects inside the Faraday's cage

Three possible artefactual effects on the Faraday's cage sensors were also examined:

4.2.2.1 Electromagnetic effect

A strong electromagnetic field was radiated by the discharge current around the discharge circuit and induced currents in surrounding conductors as well as electric fields in surrounding dielectrics. According to Maxwell's equations, these inductions should be proportional to the derivative of the discharge current. The effects of this electromagnetic field were limited by using a double Faraday's cage. The cage sensors were designed to be almost insensitive to the residual electromagnetic field. Nevertheless, weak electromagnetic field effects were recorded. However, by comparing results of discharges applied to our emitters and to metallic conductors, two effects were clearly distinguished, one (small) arising from the electromagnetic field and the other, (strong) proportional to the square of the discharge current. The second effect disappeared completely when discharges creating the same electromagnetic field were applied to a metallic conductor instead of the layered emitters.

4.2.2.2 Effect of a flux of known particles

A flux of known elementary particles (such as electrons or protons) emitted by the emitter could push matter and induce currents or electric fields. However, the energy of these particles should be smaller than 3 keV in all experiments reported here. Particles with a so small kinetic energy could not travel through materials placed along their path. Moreover, usage of flat capacitors showed that the hypothetic propelling flux could not be made of charged particles, and relatively small electric discharges in matter are not known to trigger the emission of neutrons.

4.2.2.3 Pushing effect from a continuous spectrum of electromagnetic radiation

A radiation caused by the Bremsstrahlung emission from accelerated and decelerated electrons was supposed in this analysis. However, the photons of this emission could not have an energy greater than that of the accelerated electrons (< 3 keV) so they could not travel through the interposed materials of the cryostat (1 mm thick stainless steel), Faraday's cages (2×0.8 mm thick aluminum), plus several wood supports (15–20 mm thick).

4.3 Does the emitter interact with an external energy source?

The discharge circuit appears as a "closed system" that should not generate any external momentum. However, the reported experiments showed a huge momentum transfer and the emitter support was submitted to accelerations reaching up to ten thousands g's. The effects observed are consistent with the emission by the emitter of an anisotropic propelling beam accelerating distant matter. It would explain why the emitter was pushed up, and the propelling flux should bear all the propelling momentum of the emitter. This raises the question of the origin of the energy carried by the flux. The source of energy was likely neither the emitter, because it was not progressively destroyed, nor the electric energy stored into the capacitors, because of the close to 100% efficiency found in the experiments reported in section 3.5 (expressions 3 and 5). The energy could come from an external source, for example the liquid nitrogen, but this is not consistent with the persistence of the propelling effect a few minutes after complete evaporation of nitrogen. Therefore, we suggest that an unknown interaction was triggered through the accelerated electrons inside the emitter and that the experimental

setup was an open system interacting with an external energy source. The nature of this interaction can be studied (C. Poher, 2010 b) from the experimental properties of the propelling flux as summarized now.

5. Conclusion

Main experimental properties of the propelling flux and consequences:

The flux bears a momentum proportional to the energy of the electric discharge transferred to the emitter.

It propagates in the direction of the electron acceleration inside the emitter.

The flux momentum seems to be proportional to the electron acceleration inside the emitter.

The flux is neither absorbed nor scattered by matter at rest, however it does weakly accelerate matter placed along its path (it pushes matter).

A small fraction ($\approx 10^{-6}$ per gram) of the momentum borne by the flux is transferred to irradiated matter.

The fraction of momentum transferred by the flux is proportional to the mass of irradiated matter.

The propagation speed of the flux is not known, it is much greater than 1% of c .

The flux is not made of charged particles.

It creates a sort of supersonic shock wave, when propagating through materials.

It apparently pushes electrons in dielectrics and in conductors.

It apparently pushes water molecules, generating waves.

It apparently ionizes liquid nitrogen if sufficiently intense.

These results offer the possibility to propel strongly a vehicle by applying electric discharges to a superconducting emitter without ejecting matter in space, and using only electric energy.

They also suggest the possibility of energy extraction from an unknown surrounding source, thus raising questions about the nature and properties of this source.

References

- de Matos C.J., Tajmar M. (2005). Gravitomagnetic London moment and the graviton mass inside a superconductor. *Physica C*, 432, 167, <http://dx.doi.org/10.1016/j.physc.2005.08.004>
- Murakami M. (1992). Processing of bulk YBaCuO. *Supercond. Sci. Technol.* 5, 185. <http://dx.doi.org/10.1088/0953-2048/5/4/001>
- Naoki U. et al. (1992). Furukawa El. Co. Ltd., Method of manufacturing oxide superconductor and the precursor of the oxide superconductor. *US Patent* 5106824, April 21, 1992. [Online] Available: <http://www.wikipatents.com/US-Patent-5106824/method-of-manufacturing-oxide-superconductor-and-the-precursor-of-the>
- Podkletnov E., Modanese G. (2003). Investigation of High Voltage Discharges in Low Pressure Gases Through Large Ceramic Superconducting Electrodes. *Journal of Low Temperature Physics*, 132, 239. <http://dx.doi.org/10.1023/A:1024413718251>
- Podkletnov E., Nieminen R. (1992). A possibility of gravitational force shielding by bulk YBa₂Cu₃O_{7-x} superconductor. *Physica C*, 203, 441, [http://dx.doi.org/10.1016/0921-4534\(92\)90055-H](http://dx.doi.org/10.1016/0921-4534(92)90055-H)
- Poher C. (1992). Universons, a possible key to interstellar exploration. *43rd IAF, International Astronautical Congress, Washington DC*. [Online] Available: <http://adsabs.harvard.edu/abs/1992wadc.iafcW....P>
- Poher C. (2006). Device for propelling particles by means of acceleration and applications thereof. *Europ. Patent pub.* WO 2007/093 699 A2. PCT FR 2007/000249 Feb 14, 2006. [Online] Available: <http://www.wipo.int/pctdb/en/wo.jsp?WO=2007093699>
- Poher C. (2010 b). Theoretical hypotheses. [Online] Available: http://www.universons.org/site_publication/Textes_Publication/Suppl_material_2.pdf
- Poher C., Poher D. (2010 a). Experimental video movie clips. [Online] Available: http://www.universons.org/site_publication/Emitter_Momentum.mov
- Raveau B. (1988). C.G.E., A method of manufacturing a superconductive conductor containing a ceramics superconductive material being in composition generally expressed by a formula AaBbCc. *European Patent* EP 0286823, October 19, 1988. [Online] Available: <http://patent.ipexl.com/EP/EP0283024.html>

Tajmar M., de Matos C.J. (2005). Extended analysis of gravitomagnetic fields in rotating superconductors and superfluids. *Physica C*, 420, 56. <http://dx.doi.org/10.1016/j.physc.2005.01.008>

Tajmar M., Plecescu F., Marhold K., de Matos C.J. (2006). Experimental Detection of the Gravitomagnetic London Moment. ArXiv gr-qc/060303. [Online] Available: <http://arxiv.org/abs/gr-qc/0603033>

Tajmar M., de Matos C.J. (2003). Gravitomagnetic field of a rotating superconductor and of a rotating superfluid. *Physica C*, 385, 551. [http://dx.doi.org/10.1016/S0921-4534\(02\)02305-5](http://dx.doi.org/10.1016/S0921-4534(02)02305-5)

Wu M. K., (1987). Superconductivity at 93 K in a new mixed-phase Y-Ba-Cu-O compound system at ambient pressure. *Phys. Rev. Lett*, 58, 908. <http://dx.doi.org/10.1103/PhysRevLett.58.908>

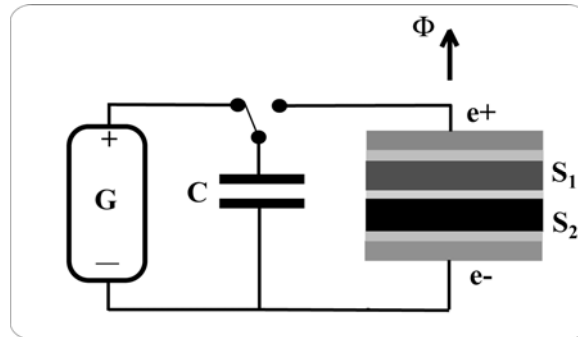


Figure 1. Principle of the experiment

An energy storage capacitor C is charged by a DC generator G to a voltage chosen between 0 and 4000 V. Then a thyristor electronic switch connects the capacitor to the layered superconducting emitter device through metallic electrodes $e+$ and $e-$ for a fast discharge. $S1$ and $S2$ are superconducting material layers. There are very thin insulated layers between $S1$ and $e+$ as well as between $S2$ and $e-$. There is a partially conducting contact between $S1$ and $S2$. The device is immersed in liquid nitrogen not shown here. Φ is the vertical axis of the device.

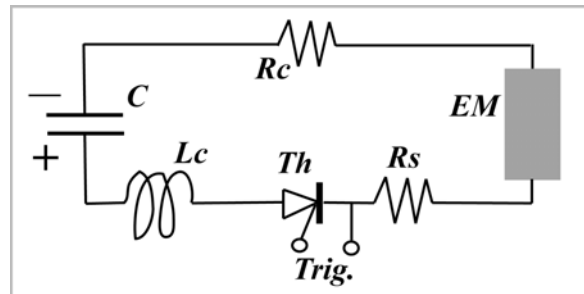


Figure 2. Circuit generating the discharge

Electric energy of the discharges is stored into capacitor C . The circuit has a distributed inductance Lc and a distributed resistance Rc . The discharges are sent into the emitter EM through the remotely-controlled thyristor Th . A fixed resistor R_s ($0.13 \pm 0.005 \Omega$) is added to avoid oscillation of the discharge current which is measured by using R_s as a shunt.

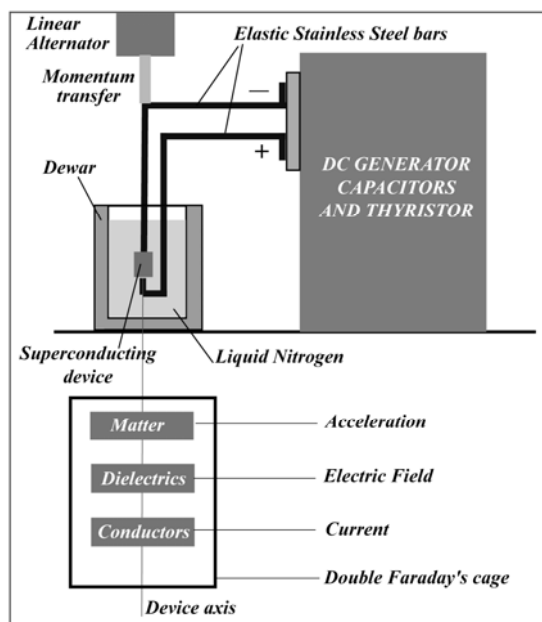


Figure 3. Experimental system

It uses four parts: - An emitter support with elastic stainless steel bars conducting the discharge current and holding the emitter in liquid nitrogen. - A discharge system, with a high voltage power supply, energy storage capacitors, thyristor switch, cryostat Dewar, and boiling liquid nitrogen. - A linear alternator which mobile magnets were pushed by an insulated momentum transfer rod. - Measuring devices enclosed in an independent double Faraday's cage, under the cryostat, along the vertical emitter axis. Eight sensors measured essentially the vertical acceleration of matter, the electric field induced inside dielectrics, and the current induced inside longitudinal conductors.

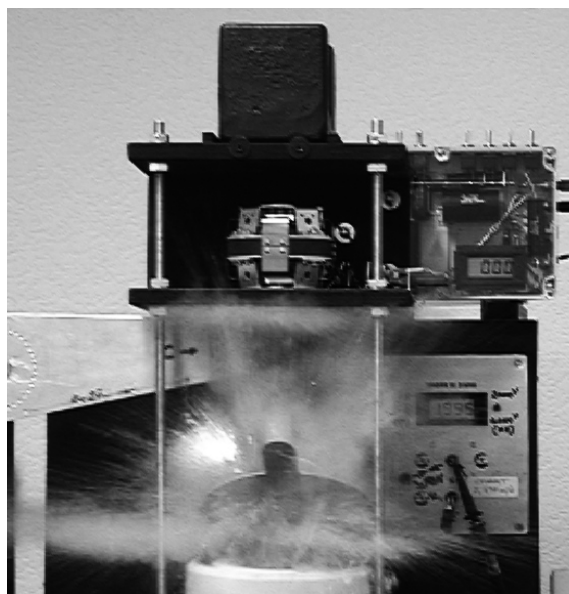


Figure 4. Propelling phenomenon, image from an experimental video movie

This still image corresponds to the beginning of a 1995 volts discharge into a pair of emitters connected in series (EM118+119). We propose a 57 seconds QuickTime movie with sound showing seven discharges of different voltages including one into a false emitter made of copper plates immersed in liquid nitrogen. The whiplash-like sound emitted is heard during each of the six discharges made into layered emitters and waves from the distant water tank are briefly observed. In this movie, the propelling momentum from the emitter is partially transferred with a delay to the linear alternator by a horizontal pendulum, for ease of observation (available online).

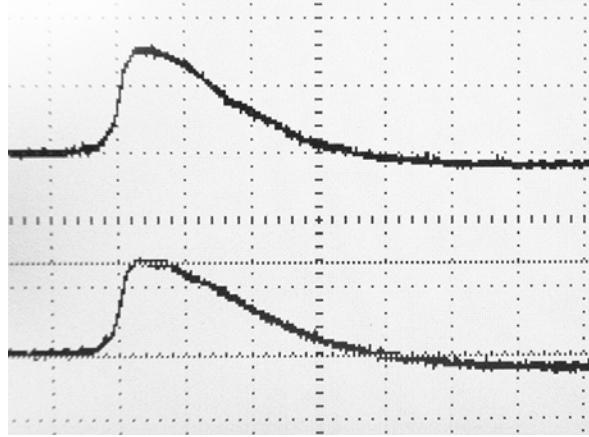


Figure 5. Emitter voltage (upper curve) and current

These were recorded during a 376 ± 1 V discharge in emitter EM3 cooled down to liquid nitrogen temperature. Peak voltage is 105 ± 2 V, peak current is 860 ± 5 A. Peak power is 90 kW. Scales: 66 ± 1 V / div, 614 ± 5 A / div, 10 ± 0.01 μ s / div.

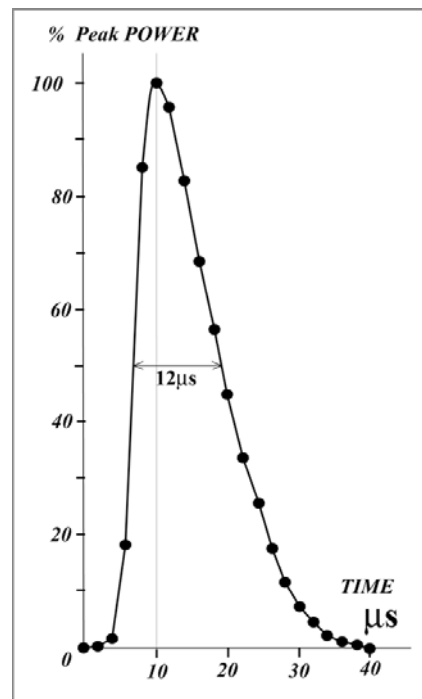


Figure 6. Electrical power versus time

Power applied to the emitter during the discharge shown in Fig. 5.

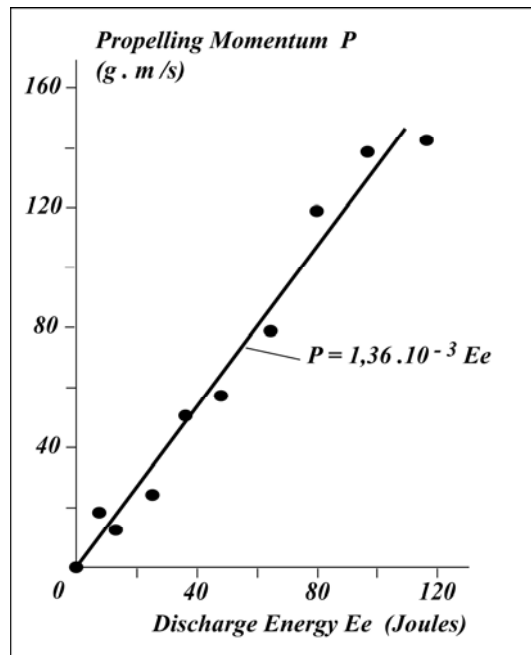


Figure 7. Typical example of propulsive momentum versus discharge energy

Momentum is proportional to electric energy of the discharge. The dot size corresponds to the measurements error (one σ).

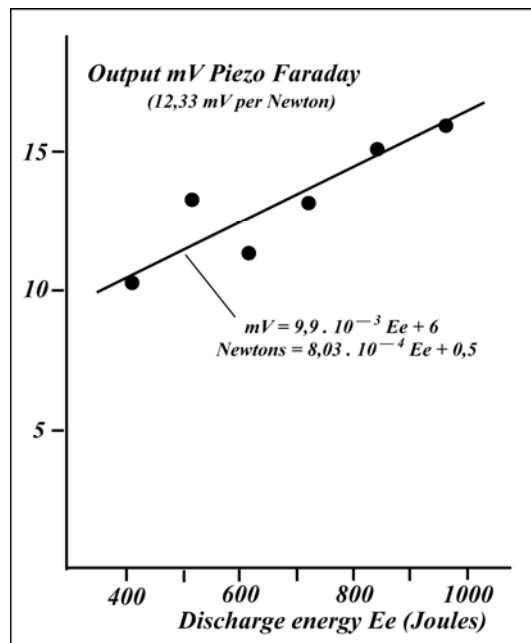


Figure 8. Typical output voltage of the piezoelectric accelerometer versus discharge energy into an emitter. The output signal is proportional to the electric energy of the discharge. The peak to peak noise was about 1 mV. This kind of accelerometer shows a bias DC voltage at rest because of the gravity acceleration.

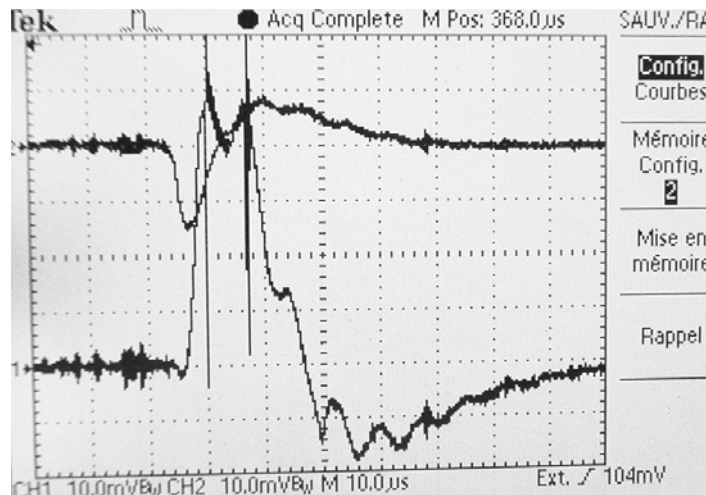


Figure 9. Output signals from two detectors separated by a distance of 95 ± 0.1 cm, recorded during a discharge in EM8 emitter

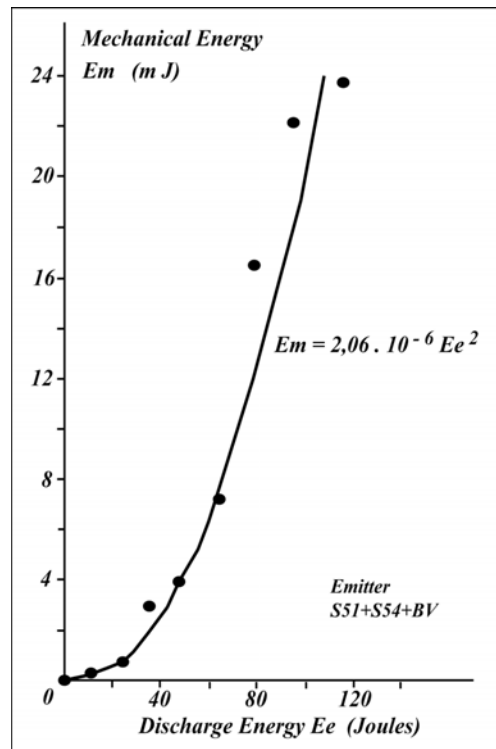


Figure 10. Kinetic energy transferred to the mobile magnets of the linear alternator, versus the electric energy into the bi-layered emitter S51+S54+BV

The evolution of output mechanical energy versus discharge electric energy is in agreement with expression (3).

SUPPLEMENTARY MATERIAL

Physical phenomena observed during electric discharges into layered Y123 superconducting devices at 77K

C. Poher and D. Poher

Laboratoire AURORA 33 Chemin de la Bourdette - 31400 TOULOUSE — FRANCE

Requests to C. Poher — Email : claude.poher@wanadoo.fr

This supplementary material is associated with the following article :

DOI :

Reproduced Abstract :

Electric discharges of several megawatts were applied, at 77 K, to propelling devices made of Y123 superconducting layers and thin insulating layers. During the discharges, the devices were strongly pushed in the direction opposed to the electron flow. The layered devices were apparently propelled by their emission of a momentum-bearing flux of an unknown nature. This flux weakly accelerated distant irradiated matter and created several physical effects not yet reported. The emitted beam had no electric charge, and traveled through materials without apparent absorption or dispersion, at a speed much greater than 1% the speed of light. The kinetic energy transferred by the propelling momentum of the devices to external masses, were proportional to the square of the electric energy of the discharges. No known effects were found which could explain these phenomena.

Links to Content

Video movies of seven discharges (to be seen with QuickTime Player or equivalent)

Annex 0 — Hypotheses about the role of the layered emitter

Annex I — The Universons model

Video movies of seven discharges

(One into a metallic conductor, Six into layered emitters)

(Two options)

The movie files sizes are 12.8 Mb in .mov format and 27.3 Mb in .avi format, therefore they take some time to load. These identical movies show seven discharges experiments recorded by the same camera situated at the same distance of three meters from the emitter, but with a different objective field of view.

These two identical movies have a much higher resolution than the one available on the journal website which size is only 3.7 Mb but shows the same events.

The first discharge (2555 Volts - 668 Joules) was done into a false emitter (control) made of a stack of two copper disks of the same size as the other Y123 layered emitters. The metallic conductor stack was also bathing in liquid nitrogen. No “schlack” sound was heard during this discharge and the horizontal pendulum did not move. The discharge instant was indicated by switching on the bright led on the left side

The next six discharges were done into Y123 layered emitters, bathing in liquid nitrogen. The corresponding discharge voltages were successively 3066, 2555, 2555, 2248, 1995 and 1200 Volts. Therefore, the momentum transferred to the long horizontal pendulum and, through it, to the upper linear alternator, increased as the square of the discharge voltage. A lot of liquid nitrogen was ejected during the most energetic discharges. The “schlack” sound recorded by the video camera microphone was heard during all discharges.

The compressed format of these movies did not allow seeing the flashes of light emitted at those six discharges instants.

[Please click here to load and see the QuickTime Player movie](#)

[Please click here to load and see the .avi format movie](#)

SUPPLEMENTARY ANNEX 0

HYPOTHESES ABOUT THE ROLE OF SPECIFIC LAYERED EMITTERS IN OUR EXPERIMENTS

Claude POHER

We propose a first hypothesis : the propelling flux emitted by our specific layered emitters during our experiments is supposed quantized, and we called “*Universons*” those quanta. Therefore we suggest the other following hypotheses, based on the Universons model (See Annex 1), in order to explain the experimental facts we reported.

In this context, the propelling flux appears simply to be an *anisotropic flux of Universons* created by the strong acceleration of electrons inside the emitter.

According to the Universons model, this flux is systematically emitted in the direction of the electrons acceleration, and its intensity is the vectorial sum of the intensities of the fluxes emitted by each individual accelerated electron. This is the inertia phenomenon.

The flux bears a momentum transferred to it by the accelerated electrons inside the emitter during Universons re-emission. This momentum moves up the emitter, because the electrons are tied to it by the strong electromagnetic field of atomic nuclei, and the emitter support is pushed up.

The emitted flux is not absorbed by matter, because the value of the capture time τ of the Universons is quite small (apparently $7.8 \cdot 10^{-14} \text{ s} \pm 10 \%$).

The anisotropic flux accelerates irradiated matter, because Universons interact weakly with all particles of matter bearing a mass. So the momentum transferred to matter is anisotropic, and proportional to the number of captured Universons, which is proportional to the mass of matter. Thus, the pushing force is proportional to the mass of matter. This is an acceleration.

The acceleration should theoretically be the same for any kind of matter, and it should also be the same for the electrons of this matter. This is effectively what is observed experimentally.

All the effects we observed experimentally were predicted by the Universons model.

Why is such a specific layered emitter necessary to create the propelling flux ?

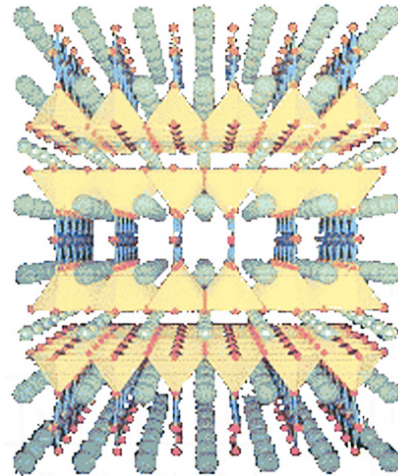
When an electric field is applied to a metallic conductor, free electrons jump from atom to atom, moving relatively slowly towards the positive end of the conductor. During each jump, electrons are submitted to the low average electric field existing inside this conductor, and they are also submitted to the strong electric field of the atomic nuclei. So electrons are successively accelerated and decelerated. Their average speed is constant, and none average macroscopic anisotropic Universons flux is emitted by the electrons in a metallic conductor.

The anisotropic emission exists only when electrons are accelerated.

Therefore, theoretically, a metallic conductor cannot emit an anisotropic Universons flux.

Fig. 1 — Alignment of atoms inside a superconducting grain, in the superconductive layers. When electrons Cooper's pairs move along the vacuum tunnels, atomic nuclei vibrate perpendicularly to the electrons direction of movement. This is the BCS theory of superconductivity.

In superconducting films of our layered emitters, about 0.6 % of the grains have their vacuum tunnels aligned along the axis of the external electrical field.



That is experimentally confirmed by our discharges into a false emitter made of a stack of copper discs.

In grains of the superconductive layers of our specific emitter, free electrons move by Cooper's pairs, inside vacuum "tunnels" (Fig. 1). Thus there is a proportion of "useful" longitudinal "vacuum tunnels" inside the superconductive grains, almost aligned along the average electric field.

The theory of high temperature superconductivity is not yet completely clear, however, for our purpose, we are going to use the BCS theory as it seems to explain what we observe.

According to BCS theory of superconduction, the arrival of the first electron attracts the atomic nuclei in a direction perpendicular to the displacement of the electron. Then the second electron is accelerated by the atomic nuclei electric field. There is a quantum exchange of phonons between the two electrons of the Cooper's pair, via crystal lattice vibrations. The result is a nil electric resistance. That phenomenon exists only in superconductors crystals.

Moreover, thanks to the very high value of the charge to mass ratio of electrons (176 billions), there is a very high acceleration of an electron by a modest electric field, in vacuum.

However, *the electric field is nil deep inside a thick superconducting material*. Therefore, a ceramic made of only one superconductor material layer cannot theoretically emit an anisotropic flux of Universons.

That was experimentally confirmed.

In our thin films emitters, there are different materials, with a similar chemical composition and a different electric behaviour. When immersed in liquid nitrogen, the two very thin layers, made of molecules of $\text{YBa}_2\text{Cu}_3\text{O}_5$, are almost insulators, the other thick layers made of $\text{YBa}_2\text{Cu}_3\text{O}_7$ are superconductive. (Fig. 2).

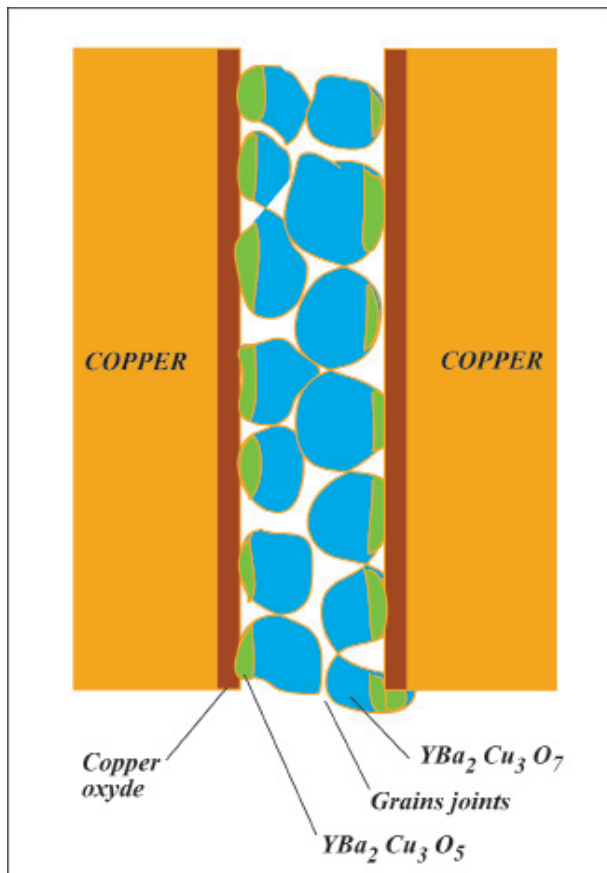
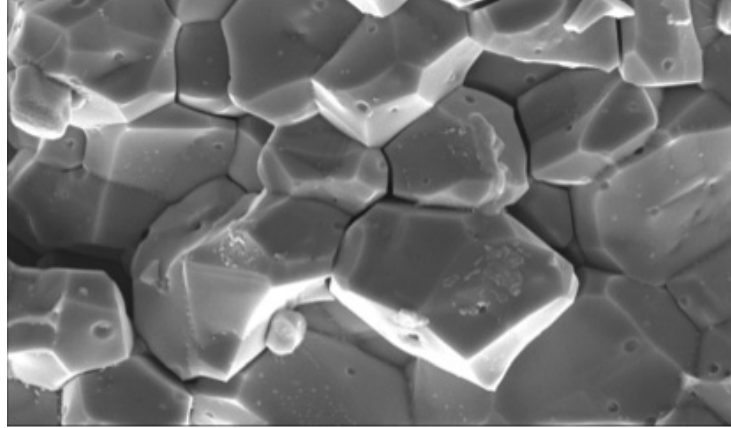


Figure 2 — Cutaway view of the composition of our specific thin films emitters (not to scale)

Fig. 3 — Electron micrograph of the emitter ceramic. Grain joints are irregular and narrow (0.1 to 0.4 microns). Electric field is concentrated at these joints.
Scale : the two upper central smaller grains have a diameter of about 10 microns.



There are also vacuum joints between the grains of superconductive layers (Figure 3). The strongest electric fields exist at the thin insulating layers and in joints between superconductive grains.

For example, during a 3000 volts discharge, there is an average electric field of about 3.6 millions V/m along a 0.1 micron distance in joints or in insulating layers.

However, this electric field of 3.6 millions V/m **does not stop abruptly at the layers or joints boundaries, it spreads largely inside the adjacent superconductive grains.**

This fact is crucial. Electrons are accelerated very strongly inside superconductive grains boundaries, close to the insulating layers and close to the joints space, and that acceleration occurs partly inside relatively long vacuum tunnels.

These highly accelerated electrons emit the anisotropic flux of Universons inside the emitter. Moreover, the anisotropic flux is then able to accelerate itself slightly the internal electrons Cooper's pairs in the roughly aligned grains of the superconductive layer of the emitter, without any electric field. There is a small auto-amplification of the emitted flux intensity.

This hypothesis was supported by the experimental emitter radiance diagram.

During a 3000 amperes discharge, where 75 % of the stored energy was flowing in 12 microseconds, electrons moved about 1,2 nm in copper electrodes, and less than 1,2 nm inside the emitter, where the current density was lower. Therefore, the behaviour of electrons, inside the superconducting layers of about 60 microns total width, dominated the macroscopic effect.

Electrons acceleration A by an electric field $E = 3.6 \cdot 10^6$ V/m is given by expression (1) where e is the electron charge and m the electron mass :

$$A = e E / m = 6.3 \cdot 10^{17} \text{ m/s}^2 \quad (1)$$

That is a very high acceleration. Moreover, there are $8.7 \cdot 10^{12}$ electrons per square millimeter of the emitters films, in a 3000 amperes current. Therefore even if only 0.6 % of them are accelerated along the aligned vacuum tunnels of the superconducting grains, that creates a quite strong anisotropic flux of Universons.

The flux intensity Φ emitted by a discharge voltage U in a circuit of resistance R is given by expression (2) in the Universons model, where D is the average distance where voltage U is applied, Eu is the energy of one Universon and c is the speed of light :

$$\Phi = U^2 c / (2 R D Eu) \quad (2)$$

This flux, emitted during an average duration of 12 microseconds, should theoretically bear a total momentum P given by expression (3), as each Universon has an Eu / c momentum :

$$P = 12 \cdot 10^{-6} U^2 / (2 R D) \quad (3)$$

Our experiments confirmed that the auto-propulsive momentum P was effectively proportional to the square of the discharge voltage U , as predicted by expression (3).

Moreover, $12 \cdot 10^{-6} U^2 / R$ is simply the electric energy transferred to the layered emitter during the discharge, so P is proportional to this energy.

And according to (3), the intensity and direction of P should not change when the voltage U is reversed. Those facts were also experimentally confirmed.

Our hypotheses are therefore supported by the phenomenological behaviour of superconducting films emitters during electric discharges.

It is however actually difficult to check the numeric exactitude of expression (3) for several reasons :

(i) — We have not yet been able to confirm experimentally the value of the energy Eu of an Universon because our accelerometers are not yet enough sensitive, and they do not have yet a sufficient bandpass.

(ii) — Distance D , where the electric field is created, varies strongly from place to place inside the layered emitters, and we have actually no way to get statistics about an “average” distance D .

(iii) — Voltage U and resistance R are measured indirectly, far from the emitter itself, during discharges with a very high $\partial I / \partial t$ (> 1 billion amperes per second). So the effect of the low distributed inductance perturbs measurements accuracy of those parameters.

However, by using plausible values for those parameters, we obtained an acceptable confirmation of expressions (2) and (3) in our experiments.

Our point of view is that the Universons model, presented succinctly in Annex I, appears to predict all the experimental phenomena we observed, and much more.

Therefore, this model should be considered benevolently as being the possible skeleton of a more elaborated theoretical model. It should possibly be improved by quantum physicists, but it should not be ignored because its simplicity does not imply it is entirely false.

That model has effectively contributed strongly to the invention and to the improvement of our patented emitters that are clearly able to propel with a demonstrated force of tens of thousands Newtons.

Experimental facts, particularly when they seem astonishing, are the basis of scientific progress, this should always be considered when looking at hypotheses.

SUPPLEMENTARY ANNEX I

THE UNIVERSONS MODEL HYPOTHESES

Claude POHER

We propose the following hypothetical model, based on special Relativity, in order to try explaining the experimental facts we reported here, and particularly the energetic field supposed to exist around our experimental system.

Several authors have proposed, since long, models of gravitation where an isotropic flux of fast moving particles travel in the Universe and interact with matter. The apparently first to have built such a model was Nicolas Fatio de Duillier (1664 - 1753) who was in contact with Isaac NEWTON. This model was formalized later by the Swiss physicist Georges-Louis Lesage in 1758.

However these models are not considered acceptable mostly because the interaction of the moving particles with matter was supposed to be an elastic collision. Effectively, with such a collision, the Inertia principle of Newton would not exist.

Nevertheless we propose here such a model where an isotropic flux of moving quanta named **Universons** is acting, but *with a new type of interaction with matter particles*.

Effectively, the interaction of our hypothetical quanta named Universons with elementary particles of matter *cannot be a classical collision*, such as in the Compton effect for example.

A very different kind of interaction should be supposed.

This new type of interaction must be closer to an absorption followed by a re-emission, like the behaviour of photons and atoms in an excitation interaction.

Duillier and Le Sage ignored, in 1758, that interactions of this type do exist in Nature.

The Universons interaction with matter *MUST be temporary*, with no energy transfer on average.

The Universons may exchange their momentum P with matter, but *this momentum must be taken back a little later*.

There can be a not nil interaction (or capture) time τ of the Universons by matter, but this capture time must be as small as allowed by the Heisenberg's uncertainty principle.

About the *travel speed of the Universons*, according to Le Sage's model, it must be as high as possible. But this speed cannot be larger than the speed of light c . As gravitation propagates at the speed of light, according to Einstein's theory, let us choose speed c for the Universons while they do not interact with matter. The speed of the Universons must be c *in all reference frames*.

According to special relativity theory an Universon bears a certain linear momentum P , corresponding to a rest mass energy E such that :

$$P = E / c$$

If the Universon comes to rest when interacting with a particle of matter, its rest mass m should then be equal to :

$$m = E / c^2$$

Evidently, we will have to consider only the interaction of Universons with elementary particles of matter bearing a mass, as such an interaction cannot be considered macroscopically. This imposes that *the rest mass m of each Universon must be much smaller than the rest mass of the less massive known particles of matter*.

We do not named «*Gravitons*» our Universons because there might be confusions with unproven past hypotheses.

Let us summarize the concept of Universons we are going to study :

There is supposed to be an interaction of matter with a flux of Universons existing everywhere in the Universe.

These Universons travel at the speed of light when they do not interact with matter, and they come from all directions of space with the average same intensity.

This means that the natural (cosmological) flux of Universons is supposed isotropic.

Each free (moving) Universon bears a momentum, and this momentum is, on average, the same for all Universons of the natural flux.

Certain Universons interact momentarily with particles of matter bearing a mass.

During this weak interaction, the Universon comes to rest, and transfers its momentum to the particle of matter.

But this is apparently not a stable situation, and after a very short time, the particle of matter spits back out the Universon in accordance with the conservation principles.

QUANTUM PHYSICS ?

A priori, the study of the Universons hypothesis should use the methods of quantum physics where the treatment of electromagnetic and Louis de Broglie's waves is the rule.

That is indeed needed when those waves manifest interference, diffraction, and dispersion. These phenomena exist because the wavelengths considered in classical quanta physics are always much smaller than the sizes of matter particles.

Here, with the Universons hypothesis, the situation is completely different, because the wavelength associated with a moving Universon is considerably larger than the size of matter particles. This because of the Universon proper energy we determined ($8.58 \cdot 10^{-21}$ Joule).

This will not be discussed into more detail in this annex. Let us only say that the Nesvizhevsky experiments in Grenoble suggest that the energy associated with one Universon is of the order of 0.05 electronvolt, so the wavelength of the Louis de Broglie's wave associated with an Universon should be of the order of tens of micrometers.

This does not allow interferences, diffractions, or dispersions when Universons interact with particles of matter, characteristic dimensions of which are about ten billion times smaller.

This fact justifies a model limited to the momentum and energy exchanges of the captured Universons with matter, using only special relativity relations.

However, a study of quantum fluctuations associated with the natural flux of Universons, in the frame of Heisenberg uncertainty principle, has confirmed a Louis de Broglie's publication in the late 1960's. We found that the average rest energy E of a captured Universon, and its average capture time τ should be narrowly dependent of the Planck's constant h :

$$E \tau = h \quad (0)$$

RELATIVISTIC NOTATIONS WE USE HERE :

Let us consider two parallel reference frames #1 and #2 (Fig.4). They are classical, with 3 perpendicular axes. Frame #1 is the one of a virtual observer at rest. He looks at the arrival of one incident Universon, from the natural flux. Frame #2 is tied to an elementary particle of matter, of mass M , and speed v in frame #1, along the Ox axis of frame #1. The speed of light c is the Universons speed in the two reference frames. We define the two classical relativistic quantities :

$$\beta = v / c \quad (1)$$

$$\gamma = (1 - v^2 / c^2)^{-1/2} \quad (2)$$

The momentum P of the Universon, or the one of the matter particle, will have subscript 1 or 2, according to the frame from where this momentum is observed. Moreover, this momentum, which is a vector, will be represented by its components along the 3 axes of each frame. So there will be one more subscript, x , y or z in order to show this.

The rest energy of the Universon will be represented by E in each frame, with the corresponding subscript.

The direction of the positive constant speed v of the particle of matter is supposed parallel to the Ox axis of each of the two frames. So, the transformation of the momentum observed in the two frames will use the following Lorentz's relativistic physics relations :

$$P_{x2} = \gamma (P_{x1} - \beta E_1 / c) \quad (3)$$

$$P_{y2} = P_{y1} \quad (4)$$

$$P_{z2} = P_{z1} \quad (5)$$

$$E_2 = \gamma (E_1 - c \beta P_{x1}) \quad (6)$$

The interaction time τ_2 of the Universon, in frame #2, is not the same when observed in frame #1 :

$$\tau_1 = \gamma \tau_2 \quad (7)$$

Moreover, as free Universons travel at constant speed c in the two frames, one can say necessarily :

$$P_1 = E_1 / c \quad (8)$$

The 3 components of the momentum P_1 of the Universon in frame #1 are tied to the incident trajectory of the Universon. Let us suppose that the Universon trajectory is in the xOy plane of frame #1, as shown in Figure 4, with an angle ϕ between the Universon trajectory and the Ox axis, we can write :

$$P_{x1} = (E_1 / c) \cos \phi \quad (9)$$

$$P_{y1} = (E_1 / c) \sin \phi \quad (10)$$

$$P_{z1} = 0 \quad (11)$$

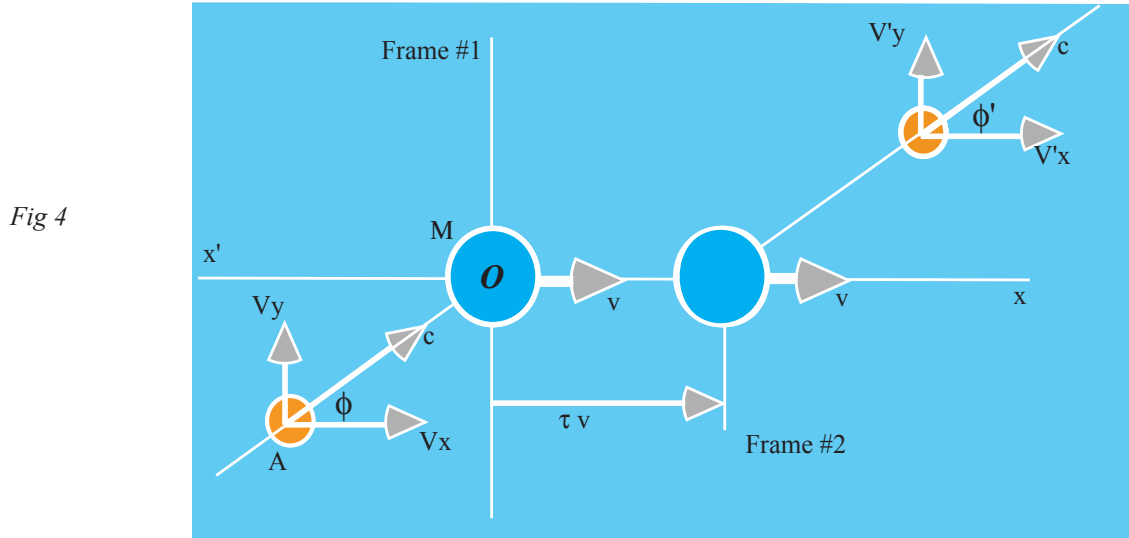
INTERACTION OF THE UNIVERSONS WITH MATTER IN UNIFORM MOVEMENT :

The first verification we need to do is evidently the compatibility of the behaviour of Universons with the Inertia principle.

This means that a constant speed particle of matter should not be perturbed by the existence of an isotropic, natural flux of Universons, interacting with it.

Let us consider the interaction of a single Universon with an elementary particle of matter bearing a mass. As previously, this particle has a constant speed v along axis Ox in frame #1. The particle is at rest in frame #2.

Figure 4 illustrates the situation in an imaginary manner.



The momentum and rest energy of the incident Universon, defined by expressions (8) to (11) in reference frame #1, do not have the same values when observed from the particle, in reference frame #2.

So, the particle of matter interacts with an incoming Universon **A** having different characteristics than the (8) to (11) ones. We have to use transformations (3) to (6) to know the values of the momentum and energy exchanged while the interaction is taking place :

$$P_{x2} = \gamma \{ (E_1 / c) \cos \phi - \beta E_1 / c \} \quad (12)$$

$$P_{y2} = (E_1 / c) \sin \phi \quad (13)$$

$$P_{z2} = 0 \quad (14)$$

$$E_2 = \gamma \{ E_1 - c \beta (E_1 / c) \cos \phi \} \quad (15)$$

Expression (12) can be written :

$$P_{x2} = (\gamma E_1 / c) (\cos \phi - \beta) \quad (16)$$

Expression (15) becomes :

$$E_2 = \gamma E_1 (1 - \beta \cos \phi) \quad (17)$$

At the very moment of the Universon capture by the particle of matter, we can suppose that its energy E_2 is changed into a mass increase m of the particle, in such a way that the relativistic equivalence of mass and energy is satisfied :

$$m = E_2 / c^2 \quad (18)$$

Or :

$$m = (\gamma E_1 / c^2) (1 - \beta \cos \phi) \quad (19)$$

Moreover, the particle of matter receives an increase of its momentum, because the impulses defined by (13), (14) and (16) are transferred to it integrally.

It is interesting to consider what should happen to the particle of matter if it would capture simultaneously another Universon, coming from a direction exactly opposed to the direction of the previous one. In this case we should consider the previous relations, but with an incidence angle $\phi + \pi$ instead of ϕ that would reverse the signs of $\sin \phi$ and of $\cos \phi$. So that for this second Universon we would observe :

$$P_{x2} = (\gamma E_1 / c) (- \cos \phi - \beta) \quad (20)$$

$$P_{y2} = - (E_1 / c) \sin \phi \quad (21)$$

$$P_{z2} = 0 \quad (22)$$

$$E_2 = \gamma E_1 (1 + \beta \cos \phi) \quad (23)$$

$$m = (\gamma E_1 / c^2) (1 + \beta \cos \phi) \quad (24)$$

The momentum transferred to the particle of matter by the two interacting Universons, along axis Oy of reference frame #2, defined by (13) and (21) are opposed and they cancel each other when observed macroscopically. Effectively, the particle interacts with a large number of Universons from an isotropic flux, so there are numerous Universons interacting simultaneously from all the directions of space.

Expressions (17) and (23) tell us the value of the energy transferred to the particle of matter by two Universons with an opposed trajectory. Those energies are not equal.

However, if we consider the effect of these two Universons on the mass increase of the particle while they interact simultaneously, we have to add expressions (19) and (24), and then we get :

$$m_{(19)} + m_{(24)} = 2 \gamma E_1 / c^2 \quad (25)$$

We observe that the total mass increase of the particle of matter is exactly the same as if two Universons of the same energy E_1 (the rest energy observed in frame #1), were interacting with the same particle, at rest, in frame #1. This is a curious but important result.

Let us stop for a moment our verification of the inertia principle compatibility, in order to consider the consequences of this fact.

THE PROPER MASS OF A PARTICLE OF MATTER :

Expression (25) demonstrates that the simultaneous capture of two incident Universons, with opposed trajectories, induces a total mass increase of the matter particle, equal, if we ignore the γ factor, to the mass increase induced by any two Universons captured when the particle is at rest. So, for the particle, being at rest or in uniform movement, does not change its mass increase, except by the γ factor, which is precisely a known result of the relativity theory.

Moreover, the interaction of one Universon with a particle of matter has a finite duration, which is a constant time τ_2 in frame #2.

Let us call F_u the intensity of the natural flux of free Universons. This intensity is measured in particular units : Universons per second, per square meter, coming from the 4π steradians.

Let us call S the « *specific capture cross section* » of Universons by particles of matter. This is not a surface, but « *a surface per kilogram of matter particle mass* ». With these units, an elementary particle of matter of rest mass M_o interacts simultaneously with n Universons, during the capture time τ_2 of one of them :

$$n = \tau_2 S M_o F_u \quad (26)$$

Each interacting pair of these n Universons, with an opposed trajectory, induces a mass increase of the matter particle given by expression (25).

So, the total mass increase M_2 caused by all the n Universons captured during time τ_2 will be the product of (25) by $n/2$:

$$M_2 = \tau_2 S M_o F_u \gamma E_l / c^2 \quad (27)$$

Replacing τ_2 by its value (7), we get :

$$M_2 = \tau_1 S M_o F_u E_l / c^2 \quad (28)$$

Now, when the capture time τ_1 has elapsed, the first captured Universons are re-emitted, and immediately replaced by new interacting ones. So the total number of permanently captured Universons remains constant and equal to n . Finally, the total mass increase M_2 of the matter particle in reference frame #2 remains constant on average, and evidently it must be equal to the observed, permanent, and constant, rest mass M_o of the particle :

$$M_o = \tau_1 S M_o F_u E_l / c^2 \quad (29)$$

So, evidently :

$$\tau_1 S F_u E_l / c^2 = 1 \quad (30)$$

Expression (30) is a ***fundamental relation*** of the Universons theory. It ties the parameters of the theory.

We might consider also that, with relation (0), we get another fundamental result :

$$S F_u = c^2 / h \quad (30 \text{ bis})$$

This expression tells us the total number of Universons permanently captured by a kilogram of matter, and permanently replaced by new captured ones, as they are re-emitted. This number is gigantic : $1.36 \cdot 10^{50}$.

According to (18) & (26), relation (30) has an important signification : the rest mass of an Universon captures only one Universon during the capture time (itself).

More than that, from the previous relations, we see that, for matter at rest :

$$M_o = n E_l / c^2 \quad (31)$$

This means that ***the rest mass of any particle of matter is made of the total energy of the simultaneously captured Universons.***

These captured Universons are continuously replaced after being captured for a very short time.

Effectively, if the capture time τ was quite long, we should have already observed the fluctuations of the mass caused by the not perfect coincidence of capture and re-emission of the pairs of Universons.

This behaviour is only acceptable if the capture time is sufficiently small so as the uncertainty principle be macroscopically respected, concerning the conservation of the energy and momentum of matter and the Universons.

Nevertheless any rest mass M_o of any particle of matter is subject to tinny and very rapid *random fluctuations*. These fluctuations follow the Laplace-Gauss's statistics, as it is the case for all particles phenomena, with the corresponding properties. For example, about 99% of the time, the rest mass of a matter particle fluctuates between $M_o - 3\sigma$ and $M_o + 3\sigma$ with $\sigma = (M_o)^{1/2}$ and a frequency of these fluctuations proportional to n/τ .

Moreover, we have shown that the observed mass M_v of a particle of matter of rest mass M_o observed from reference frame #1, when the particle moves at constant speed v relative to this frame, is, according to relativity theory :

$$M_v = \gamma M_o \quad (32)$$

that is simply the result of the capture time transformation between the two frames (7) :

$$\tau_1 = \gamma \tau_2 \quad (7)$$

This shows that the theory is correct from the relativistic point of view.

But let us now return to the main verification process of the compatibility of the theory with the inertia principle.

RE-EMISSION OF CAPTURED UNIVERSONS BY THE MATTER PARTICLE IN UNIFORM MOVEMENT :

Now, we are considering a new reference frame #3, which is frame #2 moving at constant speed $-v$ along Ox axis. Evidently, frames #1 and #3 are identical, but this will avoid errors on the subscripts in our calculations.

Each captured Universon is re-emitted at the end of the capture time τ in such a way that the average particle mass remains constant. This means that, in frame #2, energy E_2 must be exchanged between the particle of matter and the re-emitted Universon. Consequently, the momentum defined by (13), (14) and (16) is transferred to the Universon, such that the average macroscopic movement of the particle of matter is not perturbed. Those are the necessary conditions imposed by the inertia principle.

These energy and momentum, transferred to the Universon will be observed from reference frame #3, so that we will be able to compare the characteristics of the incident and re-emitted Universon in the same frame #1. The transformation of these quantities from frame #2 to frame #3 uses expressions (3) to (6), with a reverted sign for β because speed v of frame #3 is negative :

$$P_{x3} = \gamma (P_{x2} + \beta E_2 / c) \quad (33)$$

$$P_{y3} = P_{y2} \quad (34)$$

$$P_{z3} = P_{z2} \quad (35)$$

$$E_3 = \gamma (E_2 + c \beta P_{x2}) \quad (36)$$

Replacing the terms defined by (13), (14) and (16) we obtain :

$$P_{x3} = \gamma \{ (\gamma E_1 / c) (\cos \phi - \beta) + \beta \gamma E_1 (1 - \beta \cos \phi) / c \} \quad (37)$$

$$P_{y3} = (E_1 / c) \sin \phi \quad (38)$$

$$P_{z3} = 0 \quad (39)$$

$$E_3 = \gamma \{ \gamma E_1 (1 - \beta \cos \phi) + c \beta (\gamma E_1 / c) (\cos \phi - \beta) \} \quad (40)$$

Simplifying (37), we get :

$$P_{x3} = (E_1 / c) \cos \phi \quad (41)$$

Simplifying (40) :

$$E_3 = E_1 \quad (42)$$

The trajectory of the re-emitted Universon is defined by a new angle ϕ' :

$$P_{x3} = (E_3 / c) \cos \phi' \quad (43)$$

$$P_{y3} = (E_3 / c) \sin \phi' \quad (44)$$

Considering the meaning of relations (38), (39) and (42) to (44), it becomes evident that :

— On the one hand, *the re-emitted Universon has the same energy as the incident one* in frames #1 and #3 that are strictly identical.

— On the other hand, *the incidence and re-emission angles ϕ et ϕ' are equal, which means that the Universon flux remains isotropic when interacting with matter moving at constant speed.*

We can affirm that the interaction of matter in uniform movement with the natural flux of Universons does not perturb the matter movement, and does not change the isotropy of the Universons flux.

So, we have verified that this Universons theory is not in conflict with the inertia principle.

This is not sufficient to prove that the theory is correct, because there must also be a compatibility of the theory with two more phenomena :

A — On the one hand, the behaviour with accelerated matter (Newton's Inertia law).

B — On the other hand, we should also look at the behaviour when two bodies of matter are acting on each other (Newton's gravitational law).

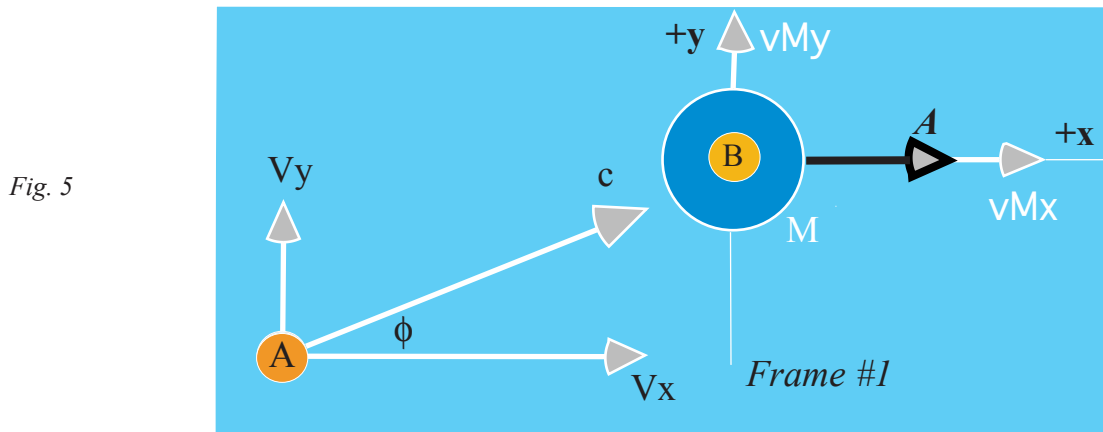
We will restrict ourselves here to demonstrations of behaviour A which concerns our emitters.

There is one important fact predicted by the Universons theory that must be taken into account for future verifications : *particles of matter are submitted to random fluctuations of their rest mass, and momentum, caused by their permanent interaction with the natural flux of Universons*. Louis de Broglie considered himself that hypothesis during the seventies.

INTERACTION OF UNIVERSONS WITH ACCELERATED MATTER :

Let us consider now the interaction of a single Universon with a particle of matter accelerated along the Ox axis of frame #1. The particle acceleration A is supposed constant, and frame #2, where the matter particle remains at rest, is supposed starting at frame #1 position at the instant of the Universon interaction.

The imaginary figure 5 helps understanding this situation, with the two frames superposed.



The incident Universon A is captured in B at the start of the frame #2 acceleration with the particle M.

The incident Universon A has the following momentum components in reference frame #1 :

$$P_I = E_I / c \quad (45)$$

$$P_{xI} = (E_I / c) \cos \phi \quad (46)$$

$$P_{yI} = (E_I / c) \sin \phi \quad (47)$$

$$P_{zI} = 0 \quad (48)$$

When the Universon is captured in position B, its energy E_I is changed into a mass increase m of the matter particle. In this capture process the relativistic equivalence of mass and energy is satisfied :

$$m = E_I / c^2 \quad (49)$$

So the particle of matter recoils because the momentum defined by (46), (47) and (48) are integrally transferred to it.

It is interesting to consider what happens with another incident Universon, coming from a direction directly opposed to the direction of the previous one. In this case we should consider an incidence angle equal to $\phi + \pi$ instead of ϕ and this would reverse the signs of $\sin \phi$ and $\cos \phi$. In this case we would get :

$$P_{xI} = - (E_I / c) \cos \phi \quad (50)$$

$$P_{yI} = - (E_I / c) \sin \phi \quad (51)$$

$$P_{zI} = 0 \quad (52)$$

$$m = E_I / c^2 \quad (53)$$

We observe that the momenta of the two Universons with opposed trajectories would compensate exactly so that the particle of matter would not move. This is true for any pair of Universons with opposed trajectories.

It is also interesting to consider what happens when two interacting Universons are simultaneously coming from symmetrical directions relatively to +x. In this case we should consider an incidence angle equal to $-\phi$ instead of ϕ and this would reverse only the sign of $\sin \phi$ and not the one of $\cos \phi$. Then we would get :

$$P_{xI} = (E_I / c) \cos \phi \quad (54)$$

$$P_{yI} = - (E_I / c) \sin \phi \quad (55)$$

We observe that the momenta transferred to matter by the two Universons with symmetrical trajectories would compensate exactly in the y direction, but would add in the x direction of the acceleration.

Exactly at the beginning of the capture time τ we suppose that an external cause creates the acceleration A of the particle of matter which begins to move along axis x.

The observer remains in frame #1. Effectively, the Lorentz's equations that we used previously are not adapted to accelerated frames.

So we are going to suppose that the capture time τ of the Universon by the matter particle is observed from this #1 frame.

The whole elementary particle of matter is supposed accelerated by an external cause, from the beginning of time count (time zero). And this is also supposed to be exactly the beginning of the Universon capture.

As soon as it is captured, the Universon disappears, and is changed into a part m of the matter particle mass. And we are going to consider that this mass element m is now the bearer of the energy and of the momentum of the captured Universon.

This is of course a purely pedagogical method for studying the interaction, because nothing distinguishes this mass element from others. This simple method gives correct results and is easy to understand.

Thus, the elementary matter particle mass element m has the following momentum and energy at instant $t = 0$, when the Universon has just been captured :

$$\begin{aligned} P_{x1} &= (E_1 / c) \cos \phi \\ P_{y1} &= (E_1 / c) \sin \phi && \text{(previous relations 46 to 49)} \\ P_{z1} &= 0 \\ m &= E_1 / c^2 \end{aligned}$$

The total energy E_{m0} of the mass element m is expressed by the following relation at instant zero :

$$E_{m0} = m c^2 \quad (56)$$

Then, during the capture time τ the matter particle and its mass element m are accelerated by an external cause along the x axis of frame #1.

Consequently, their speed increases versus time. And their momentum and kinetic energy increase accordingly.

Now let us consider instant $t = \tau$ in frame #1, just before the Universon re-emission.

We are now going to look at the previous quantities at the end of capture time τ just ***before*** the Universon is re-emitted. The variables indices 1 become 1τ for clarity.

The matter particle is moving now at speed

$$v = A \tau \quad (57)$$

in frame #1, along the x axis.

In relativistic physics, the momentum P acquired by a matter particle of mass m moving at speed v is given by the expression :

$$P = m \gamma v \quad (57-1)$$

where the parameter γ has the value defined by expression (2). Moreover, according to (2), and (49) and (57) we can write :

$$P = (\beta \gamma) E_1 / c \quad (57-2)$$

The total energy E of this same matter particle is given by the following expression :

$$E = \gamma m c^2 \quad (57-3)$$

And the kinetic energy E_c of this particle is expressed by :

$$E_c = m c^2 (\gamma - 1) \quad (57-4)$$

In those expressions, let us recall that the mass m is the one caused by the Universon capture and defined by expression (49) :

$$m = E_1 / c^2 \quad (49)$$

So, the mass element m of the elementary particle of matter has the following components of its momentum, and the following total energy at the instant $t = \tau$ in frame # 1, just before the Universon re-emission :

$$\begin{aligned} P_{x \mid \tau} &= (E_I / c) (\cos \phi + \beta \gamma) \\ P_{y \mid \tau} &= (E_I / c) \sin \phi & (58 - 1 \text{ to } 58 - 4) \\ P_{z \mid \tau} &= 0 \\ E_{m \mid \tau} &= \gamma E_I \end{aligned}$$

And exactly after this instant, the Universon is re-emitted and the mass increase m disappears.

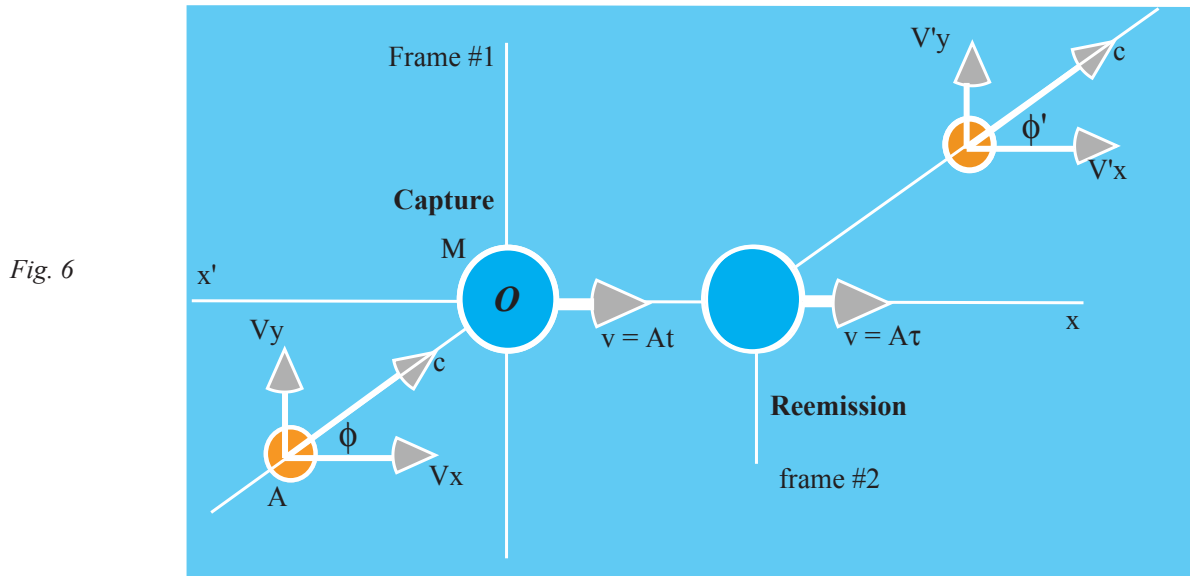
But we must not forget that the matter particle captures and re-emits Universons *permanently*. And this is the reason why the matter particle mass remains constant on average. So the mass element m does not simply disappear, it is replaced by another one, created by the capture of another Universon, other mass element which is identical, and which is taking care of the momentum and kinetic energy.

RE-EMISSION OF THE UNIVERSION BY THE ACCELERATED MATTER PARTICLE :

At the end of the capture time, the previously captured Universon recovers its freedom.

We know, by experiments, that the total average mass of the matter particle does not change, and that its average kinetic energy is the one predicted in the absence of interaction with Universons.

The Universon re-emission is represented on Figure 6. The observer remains in frame #1 as previously.



As the Universon interaction with the matter particle does not change the average mass of matter, and does not change its final kinetic energy, it is essential that the re-emitted Universon energy E_τ be equal to :

$$E_\tau = E_{m \mid \tau} = \gamma E_I \quad (59 - 1)$$

The corresponding momentum P_τ is equal to :

$$P_\tau = E_\tau / c = \gamma E_I / c \quad (59 - 2)$$

Precisely, the Universons re-emission must not be the cause of a supplementary modification of the matter particle speed. This implies necessarily :

$$P_\tau = P_{xI\tau} = (E_I / c) (\cos \phi + \beta \gamma) \quad (59 - 3)$$

If we call ϕ' the re-emission angle of the Universon in frame #1, according to figure 31, we know that, by definition :

$$P_\tau = (E_\tau / c) \cos \phi' \quad (59 - 4)$$

So, with (59 - 1) and (59 - 2) :

$$P_\tau = \gamma (E_I / c) \cos \phi' = (E_I / c) (\cos \phi + \beta \gamma) \quad (59 - 5)$$

Which simplifies the following way :

$$\cos \phi' = (1 / \gamma) \cos \phi + \beta \quad (59 - 6)$$

However, we know that $\beta = v / c$ with a speed $v = A \tau$ (57) which is always extremely small, whatever the value of the acceleration A because the capture time τ is extremely brief. In these conditions, the value of the parameter :

$$\gamma = (1 - v^2 / c^2)^{-1/2} \quad (2)$$

is always equal to one with an error inferior to 10^{-39} and equation (59 - 6) can be simplified :

$$\cos \phi' = \cos \phi + A \tau / c \quad (59 - 7)$$

The expressions system defining the Universon re-emission conditions becomes :

$$\begin{aligned} P_{xI\tau} &= (E_I / c) \cos \phi' \\ P_{yI\tau} &= (E_I / c) \sin \phi' \\ P_{zI\tau} &= 0 \\ E_{mI\tau} &= E_I \end{aligned} \quad (60 - 1 \text{ to } 60 - 4)$$

In frame #2, tied to the accelerated matter particle, the momentum and the kinetic energy of the particle are null.

Consequently, relations (60) represent the characteristics of the re-emitted Universon as seen by the observer situated in frame #1.

Let us examine the direction of the Universon re-emission by comparing the angles ϕ of capture and ϕ' of re-emission, both measured from the axis x in frame #1.

According to definition (59 - 7) let us recall that these angles are tied by expression :

$$\cos \phi' = \cos \phi + A \tau / c \quad (59 - 7)$$

INTERPRETATION OF THESE RESULTS :

Interpretation of relations (59 - 7) and (60) reveals several facts :

1 — The angles of incidence ϕ and of re-emission ϕ' of the Universons are not equal. There exists an ***anisotropy of the re-emitted flux of captured Universons.***

2 — The momentum communicated to the accelerated particle of matter by the Universon interaction ***is, in the direction opposed to the acceleration, different*** than in the acceleration direction.

It suffice effectively to compare expressions (46) and (60 -1) to draw this conclusion.

This explains the inertia effect, and the need to exert a force on matter in order to be able to accelerate it. More calculation about that below.

3 — This difference in capture and re-emission momentum manifests itself the same way in all space around the particle.

The anisotropy of the re-emitted flux of captured Universons, by accelerated matter, concerns all space around the particle of matter. This anisotropy has a revolution symmetry around the acceleration direction.

4 — The compensation of the momentum transferred to matter perpendicularly to the acceleration direction, by the interaction with the Universon flux, does not appear Universon by Universon, but from pairs of captured Universons with opposed or symmetric incident trajectories, according to the acceleration direction.

The conservation of energy, and the one of momentum, are only true at macroscopic scale, on average. The uncertainty principle authorizes this behaviour if the capture time of the Universons' pairs is sufficiently small, which is the case.

5 — Taking into account the fact that, for all practical acceleration values, $A\tau/c \lll 1$ which means that $\gamma = 1$, expression (62) becomes :

$$\cos \phi' = \cos \phi + A\tau/c \quad (61)$$

Now, let us consider the solid angle Ω' defined by a cone with the half summit angle ϕ' because the interaction is symmetric around the direction of the acceleration. The axis of this cone is the acceleration direction.

When $\phi = \pi$ then, expression (63) can be written :

$$\cos \phi' = -1 + A\tau/c \quad (62)$$

From definition of solid angle :

$$\Omega' = 2\pi (1 - \cos \phi') \quad (63)$$

With (62) we obtain :

$$\Omega' = 4\pi - 2\pi A\tau / c \quad (64)$$

This is the full sphere plus the solid angle :

$$\Omega' = -2\pi A\tau / c \quad (65)$$

In this very small solid angle Ω' , situated in the opposite direction of the acceleration, the accelerated particle of matter does not re-emit any captured Universon.

This explains how the re-emitted flux can be anisotropic.

6 — In expression (61), if $\phi = 0$ then :

$$\cos \phi' = 1 + A\tau/c \quad (66)$$

But, as $A\tau/c$ is positive, this expression is impossible, because the cosine of the re-emission angle cannot be larger than one. Interpretation of this fact is evidently that, *in a very small solid angle* :

$$\Omega = 2\pi A\tau / c \quad (67)$$

Situated in the direction of the acceleration, around $\phi = 0$, the accelerated particle of matter does not capture any Universon coming from this solid angle.

These un-captured Universons continue their trajectory, as if matter was not there. So, in the direction of the acceleration, entirely inside the solid angle Ω , the incident, natural flux of Universons, is not perturbed.

7 — We can write expression (63) the following way :

$$2\pi (1 - \cos \phi') = 2\pi (1 - \cos \phi) - 2\pi A\tau / c \quad (68)$$

Or, according to (63) :

$$\Omega' = \Omega - 2\pi A\tau / c \quad (69)$$

This expression shows that for an incident solid angle $\Omega = 4\pi A\tau / c$ the re-emission solid angle is only $\Omega' = 2\pi A\tau / c$ or two times less.

But we already know that, for all Universons coming in the solid angle $\Omega = 2\pi A\tau / c$ there is no capture. This means that they simply continue their trajectory and emerge in the solid angle $\Omega' = 2\pi A\tau / c$;

However in this same emergence solid angle, there are also the Universons re-emitted after capture in the periphery of the incident solid angle $\Omega = 4\pi A\tau / c$.

So the **OUTPUT flux** of Universons, from the accelerated particle of matter, ***in the direction of the acceleration***, and only in the solid angle $\Omega' = 2\pi A\tau / c$ ***is always LARGER, than in the opposite direction***, where the captured Universons are not re-emitted.

So, considering facts #5 and #7 about the anisotropy of the interaction with an accelerated particle of matter, *there are two particular, very small solid angles $\Omega = 2\pi A\tau / c$, of the same value, to consider. Both solid angles have the same axis, which is the acceleration direction, but they are opposed by their summit.* One of these two solid angles is opened towards the front, the other one towards the rear.

In the front solid angle, the output flux of Universons is increased. In the rear solid angle, incident Universons are not captured.

CALCULATION OF THE INERTIA FORCE :

According to (59 - 7) expression (60 - 1) can be written :

$$P_{x1\tau} = (E_I / c) (\cos \phi + A\tau / c) \quad (70)$$

We know that this is the momentum transferred to the particle of matter by the re-emitted Universon, with a negative sign (in the direction $-x$).

Let us compare this momentum with the one transferred to the particle of matter, in the $+x$ direction, by the captured Universon. It was given by expression (46) :

$$P_{x10} = (E_1 / c) \cos \phi \quad (46)$$

So now, by subtracting directly (46) from (70) we get the total momentum transferred to the matter particle, along the minus direction of the x axis, by the interaction of a single Universon :

$$\Delta P_x = (E_1 / c) (A\tau/c) \quad (71)$$

The residual momentum (71) impedes the acceleration of the matter particle. This fact justifies the inertia effect, and the need to exert an external force in order to accelerate the matter particle.

The elementary force δf that must be applied to the element of mass m of the matter particle, in order to compensate the back momentum delivered by the interaction of a single Universon during time τ must be, in principle, such that :

$$\delta f = \Delta P_x / \tau = E_1 A / c^2 \quad (72)$$

We are going to verify if this is correct.

In reality, we want to verify that this theory is compatible with the Newton's law of inertia.

So, we have to determine the value of the force, acting on the accelerated particle of matter by the difference in linear momenta induced by the Universons interaction. The particle of matter has a total rest mass M_0 .

Let us call F_u the intensity of the natural Universons flux, as previously. This flux is again expressed in Universons per second, in the 4π steradians.

This incident flux F_u is isotropic, so the partial flux $\delta F(\phi, \psi)$ per steradian, in a direction defined by angles ϕ and ψ is equal to :

$$\delta F(\phi, \psi) = F_u / 4\pi \quad (73)$$

We will consider incident Universons, coming from direction ϕ, ψ where the angle ϕ is, as previously, measured in the xOy plane, and angle ψ in the yOz plane.

Again, let us call S the specific capture cross section of matter for the Universons interaction. So the flux $\delta F_c(\phi, \psi)$ of the captured Universons, coming in the direction ϕ, ψ is given by :

$$\delta F_c(\phi, \psi) = S M_0 F_u / 4\pi \quad (74)$$

This flux is expressed in captured Universons per second and per steradian, in the (ϕ, ψ) direction.

The number of Universons $\delta N(\phi, \psi)$ simultaneously captured, from this direction, during the capture time τ of one of them is equal to :

$$\delta N(\phi, \psi) = \tau \delta F_c(\phi, \psi) = \tau S M_0 F_u / 4\pi \quad (75)$$

Each one of these captured Universons transfers, to the particle of matter, when re-emitted, a supplementary momentum, in the direction opposed to the acceleration, which value is given by (71) copied here :

$$\Delta P_x = (E_1 / c) (A\tau/c) \quad (76)$$

For each re-emitted Universon, the elementary force δf exerted on the particle of matter, at the end of time τ is simply equal to $\Delta P_x / \tau$:

$$\delta f = \Delta P_x / \tau = A E_l / c^2 \quad (77)$$

So, the $\delta N(\phi, \psi)$ captured Universons during this time τ , coming from the direction (ϕ, ψ) are exerting a total force, which is given by the product : $\delta f \delta N(\phi, \psi)$.

The total force acting on the particle of matter for all the Universons coming from all the directions of space is obtained by integrating the value of this product in all space. This means that, by varying angle ϕ from 0 to π , and angle ψ from 0 to 2π , we get :

$$\text{Force} = (2/\pi) \int_{\phi=0}^{\phi=\pi} \int_{\psi=0}^{\psi=2\pi} \tau S M_0 A E_l F_u / (4\pi c^2) \delta\phi \delta\psi \quad (78)$$

Finally :

$$\text{Force} = \tau S M_0 A E_l F_u / c^2 \quad (79)$$

But, from (30) we already know that :

$$\tau S F_u E_l / c^2 = I \quad (30)$$

So, expression (85) becomes :

$$\text{Force} = \mathbf{M}_0 \mathbf{A} \quad (80)$$

That is simply the well known Newton's inertia law.

So, *the Universons model is compatible with the Galileo's Inertia principle AND with the Newton's inertia law.*

A SIMPLER METHOD FOR THE FORCE DETERMINATION :

We have shown (76) that no Universon is re-emitted in a solid angle $\Omega' = -2\pi A\tau/c$, opposed to the direction of the acceleration. Macroscopically speaking, this means that incident Universons, coming from the direction opposite to the acceleration direction, into this solid angle, transfer to the particle of matter, a momentum, opposed to the direction of the acceleration, which is not compensated.

Moreover, incident Universons coming in the direction of the acceleration, in a solid angle $\Omega = 2\pi A\tau/c$, which axis is the direction of the acceleration, are not captured. Macroscopically speaking, this means that the re-emitted Universons in the direction of the acceleration direction, into the same solid angle, transfer to the particle of matter, a momentum, opposed to the direction of the acceleration, which is not compensated.

So the solid angle value $\Omega = 2\pi A\tau/c$ acts *two times* on the momentum transferred macroscopically to matter, in the opposite direction of the acceleration.

Expression (75) gives the average number of Universons captured, per steradian, during time τ in the (ϕ, ψ) direction. So the product of expression (82) by **two times** the value of the solid angle $\Omega = 2\pi A\tau/c$, should be the average number N_Ω of Universons exchanging a momentum in these solid angles :

$$N_\Omega = 2 \Omega \delta N(\phi, \psi) \quad (81)$$

$$N_\Omega = A\tau^2 S M_0 F_u / c \quad (82)$$

Each one of these Universons transfers to the particle of matter a momentum E_l / c and the force is equal to the momentum divided by time duration τ so :

$$\text{Force} = N_{\Omega} E_l / c \tau = A \tau S E_l M_0 F_u / c^2 \quad (83)$$

But, from (30) we know that :

$$\tau S F_u E_l / c^2 = I \quad (30)$$

So :

$$\text{Force} = A M_0 \quad (84)$$

Which is as correct as (80).

This means that, in order to obtain the force acting on an accelerated particle of matter, it suffices, macroscopically, to determine the number of Universons captured in the solid angle $\Omega = 2\pi A \tau / c$, and then to multiply this number by $2 E_l / \tau c$. And finally, take into account fundamental expression (30).

CONCLUSION OF ANNEX I :

Finally, we have demonstrated that :

A — The *Universons model is compatible with the Galileo's Inertia principle AND with the Newton's inertia law.*

This is in fact sufficient to explain our experiments with our specific emitters.

However we have also concluded, from *demonstrations not reproduced here* that :

B — The *Universons theory is also compatible with Newton's gravitation law.*

So we can hope that this model constitutes another possibility to understand these two fundamental natural phenomena.

Particularly because the predictions of this model are also corroborated by a large amount of observations. We are not going to include these long studies in this short publication of experimental results. However, let us summarize our point of view based on facts from these studies :

— The Universons model predicts new facts. And these facts are effectively observed. They are tied to the Universe expansion and to the random fluctuations associated with the Universons flux quantization.

— On the one hand, the Universe expansion introduces a very tinny supplementary constant acceleration Hc that adds to any acceleration in the Universe, whatever the cause of the main acceleration. H is the Hubble constant and c the speed of light.

— On the other hand, the quantization of gravitational acceleration implies random fluctuations, and a particular behaviour at very low acceleration levels is predicted, because of the presence of the acceleration Hc .

— Thanks to these predictions, quite old observation results, unexplained until now, found simple and evident justifications without calling for unobserved dark matter hypothesis.

These are the quasi constant orbital speed of the stars in spiral galaxies, the proper speed of galaxies in clusters, or the observed constant supplementary acceleration Hc of all distant interplanetary spacecrafts.

Evidently, these predictions have also important cosmological consequences, because they wipe out the existence of the dark matter hypothesis, concerning the main constituent of the Universe. Dark matter is replaced by the cosmological Universons flux which is isotropic.

This is, without doubt, one of the most important aspects of the Universons model, enhanced by the reality of its predictions in the experimentation with our specific emitters.

When considering the hypotheses at the root of this model we should think that there exists, everywhere in the Universe, a quantized flux of energy of an extraordinary power. Accelerated matter seems able to extract directly kinetic energy from this flux, and the flux appears to be the cause of the mass of matter in all the Universe.

This is a perspective that surpass quite largely the frame of the tentative done to explain our laboratory experiments with superconducting emitters.

Therefore, quantum physicists should not ignore those facts, and should seriously consider to exert their skills at the improvement of this model.

© Claude POHER — December 20, 2010.